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CALIFORNIA STATE COMMISSION OF HORTICULTURE

Injurious and Beneficial Insects



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of
California

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SUPPLEMENT
THE MONTHLY BULLETIN
CALIFORNIA STATE COMMISSION OF HORTICULTURE

INJURIOUS AND BENEFICIAL

Insects of California

(SECOND EDITION)

BY
E. O. ESSIG

FOREWORD.

Insect devastation costs the United States millions of dollars annually. California bears her full share, two millions being a reasonable estimate. Wise and timely application of well-known remedies would save much of this constant loss. Mr. E. O. Essig's signal success in the discovery and practice of control measures pointed him out as one fit to instruct the public as to the life histories of insects and the best methods to control their attacks. This led to the publication by the State Commission of Horticulture two years ago of "Injurious and Beneficial Insects of California." Anticipating a great demand for the book, a very large edition was issued. These anticipations were greatly exceeded, and very soon the edition was wholly exhausted. Commendation of the work was most hearty and reached the Commission from all countries, far and near. The call for another edition was loud and general. The Commission is greatly pleased to heed this request in the present enlarged and improved edition, which it feels sure will be very heartily welcomed.

A. J. COOK,

State Commissioner of Horticulture.

PREFACE.

The second edition of "Injurious and Beneficial Insects of California" has been published at the request of Dr. A. J. Cook, State Commissioner of Horticulture, to meet the many demands for the first edition, which was exhausted soon after its appearance as Nos. 1 and 2, Vol. II, The Monthly Bulletin of the State Commission of Horticulture, January and February, 1913. Since that time the author has made many additions and corrections so that the present work is very much larger than the first. While the general scope of the publication is practically the same, many insects of minor importance have also been included, because of the demands upon the commissioner's office concerning them. Household insects and those attacking domestic animals are largely omitted, not because they are any less important than many that are included, but because time and space would not permit of the larger undertaking.

The arrangement is systematic, following the classification of insects rather than of host plants so commonly used in recent works of economic entomology. This was done with the desire of making it possible for the reader to acquire a more comprehensive knowledge of the relationships of insects, which forms the basis of all real intelligent methods of control. The host plant index in the front permits one to readily follow out the host plant arrangement if so desired.

The work is intended primarily for fruit growers and farmers and technicalities are avoided wherever not absolutely necessary, but it is hoped that entomologists may find it of some value also.

The writer has drawn freely from all available sources of systematic and economic entomological literature and especially from the bulletins of the Bureau of Entomology, United States Department of Agriculture, of the United States National Museum, of the California Agricultural Experiment Station and the agricultural experiment stations of other states; from such publications as the Annals of the Entomological Society of America, The Journal of Economic Entomology, The Monthly Bulletin of the California State Commission of Horticulture, Entomological News, Canadian Entomologist, The Pomona College Journal of Entomology and Zoology, The Review of Applied Entomology, and publications of a similar nature; from such works on entomology as "Injurious Insects of the Orchard, Vineyard, Etc.," by Matthew Cooke; "Insect Pests of Farm, Garden and Orchard," by E. Dwight Sanderson; "Biennial Crop Pest and Horticultural Report of the Oregon Agricultural College Experiment Station (report of the Department of Entomology), 1911-1912 and

1915," by H. F. Wilson and A. L. Lovett; "Guide to California Insects," by C. W. Woodworth; "Manual of Fruit Insects," by M. V. Slingerland and C. R. Crosby; "Insects Injurious to Fruits," by W. Saunders; "Injurious Insects," by W. C. O'Kane, and many other works. The bibliography is largely included in the footnotes which are numbered consecutively throughout. All references are also indexed under the author's name in the general index.

Five copies of the manuscript were prepared and sent to specialists with the request that the contents be severely criticised and such corrections and suggestions made as should be required to make the finished product accurate and reliable. Thus the entire copy has passed through the hands of many experts with the most gratifying results and is really the product of many workers. For the very valuable assistance rendered in this connection the author wishes to express his sincere appreciation and thanks; to the members of the California State Commission of Horticulture and especially to the commissioner, Dr. A. J. Cook, who has made the publication of both editions possible; to Mr. Geo. P. Weldon, chief deputy commissioner; to Mr. Harry S. Smith, superintendent of the State Insectary, and to Mr. E. J. Vosler, secretary of the commission, for reading all of the manuscript and proof; to Mr. Vosler also for superintending the printing; to Prof. C. W. Woodworth, University of California, and Prof. R. W. Doane, Stanford University, for looking over the manuscript; to Dr. R. V. Chamberlin, Harvard University, for revising the *Diplopoda*, *Symphyla* and *Chilopoda*; to Mr. Geo. P. Weldon also, for revising the *Arachnida* and the article on the fruit-tree leaf-roller; to Mr. Nathan Banks, United States Department of Agriculture, for revising the *Arachnida* and the *Neuroptera*; to Mr. Paul R. Jones, San Francisco, Cal., for looking over the *Thysanoptera* and writing the methods of controlling the pear thrips (the scientific names of the thrips have been taken from the writings of Mr. J. D. Hood); to Prof. Lawrence Bruner, University of Nebraska, and Mr. A. N. Caudell, United States National Museum, for revising the *Orthoptera*; to Prof. R. W. Doane, Stanford University, and Mr. Geo. A. Coleman, University of California, for revising the *Coccidæ*; to Prof. C. P. Gillette, Colorado Agricultural College, Mr. John June Davis, United States Department of Agriculture, Prof. H. F. Wilson, Oregon Agricultural College, and Mr. W. M. Davidson, United States Department of Agriculture, for a very careful revision of the *Aphididæ*; to Mr. E. P. Van Duzee, University of California, for looking over the *Cicadidæ*, *Membracidæ*, *Jassidæ* and *Heteroptera* (the recent works of Prof. A. L. Quaintance and Mr. A. C. Baker, United States Department of Agriculture, have been followed in the classification of the *Aleyrodidæ*); to Dr. Edwin C. Van Dyke, University of California,

and Prof. H. C. Fall, Pasadena, Cal., for a very careful revision of the *Colcoptera*; to Prof. J. M. Aldrich, United States Department of Agriculture, for revising the *Diptera*; to Mr. W. M. Davidson also for looking over the *Syrphidæ*; to Mr. Harry S. Smith also for revising the *Hymenoptera*; to Dr. Harrison G. Dyar and Mr. August Busck, United States National Museum, and Mr. Fordyce Grinnell, Jr., Pasadena, Cal., for revising the *Lepidoptera* (the classification of Dr. Geo. F. Hampson has been largely followed in the *Lepidoptera*, especially in the *Noctuidæ*); to Mr. Geo. P. Gray, University of California, for revising the articles on spraying and fumigating; to Mr. Leroy Childs, Oregon Agricultural College, for much assistance in gathering field notes and material when he was assistant secretary of the Commission of Horticulture; to Mr. S. H. Essig, horticultural inspector of Ventura County and brother of the author, especially for the many splendid specimens sent for illustrative purposes; to Miss Maude Hiett, clerk of the State Commission of Horticulture, for assisting in reading the manuscript and proof, and to Mrs. Nellie Mitchell and Mrs. E. Stephens for their painstaking work in copying the manuscript.

Unless otherwise designated, the illustrations were either drawn or photographed by the author and used in previous writings or here for the first time.

The work was begun and largely finished while the author was a member of the State Commission of Horticulture, and, upon his transfer to the University of California, arrangements were made whereby he has been able to finish it with little or no interruption. The generosity of the University authorities in this connection is very greatly appreciated by the author and the State Commission of Horticulture.

E. O. ESSIG.

Berkeley, California, May 1, 1915.

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GENERAL CLASSIFICATION

Insects belong to the phylum *Arthropoda*, a group of animals having jointed bodies and jointed legs. In the same phylum are to be found the following classes:

1. **Crustacea**.—Water and land animals, with five or more pairs of legs; two pairs of antennæ; and hard exoskeleton; head and thorax united. Examples: crabs, lobsters, crayfish and sowbugs.

2. **Arachnida**.—Land forms; antennæ absent; four to eight legs, head and thorax united. Examples: scorpions, solpugids, spiders, mites and ticks.

3. **Malacopoda**.—Land forms; body worm-like with numerous legs. Very peculiar animals which are seldom met with. Example: *Peripatus*.

4. **Diplopoda**.—Land forms; body long, cylindrical, chitinized, many segmented; legs short, attached close together on the ventral surface, usually two pairs to a segment; antennæ short. Examples: millipeds or thousand-legged worms.

5. **Symphyla**.—Land forms; body small, slender, rather flattened with soft whitish integument, many segmented; twelve pairs of legs in adults, less in young, single pair to a segment, attached wide apart near sides, no poison jaws present; antennæ quite long. Example: the lima bean symphyliid.

6. **Chilopoda**.—Land forms; body long, flat, many segmented, somewhat chitinized; fifteen or more pairs of legs in adults, a single pair to a segment, attached wide apart, first pair modified into poison jaws; antennæ quite long. Examples: centipedes.

7. **Insecta or Hexapoda**.—Aquatic and terrestrial, but primarily the latter. Body of the adults divided into three distinct regions: head, thorax and abdomen. Adult forms with six legs. Many are winged. Transformations or metamorphoses occur in all except the lowest order, *Aptera*, which has only primitive transformations. Examples: insects.

CRUSTACEA (Class)

SOWBUGS, CRAYFISH, LOBSTERS, CRABS, ETC.

At first thought few persons in California would think of any members of this class as injurious to the crops grown in the State and would probably need to be reminded that the common sowbugs so very abundant in gardens and greenhouses belonged in this class. It is because of the much alleged serious damage done by these sowbugs that it has been thought best to include a few words relative to at least one of the common species.

THE DOORYARD SOWBUG

Porcellio lævis Koch¹

(Fig. 1)

Description.—The photograph (Fig. 1) gives a very good idea of the general appearance of sowbugs. The color is dull slate above and light grayish beneath. The outer covering is rather hard and resembles a number of articulating plates. There are seven pairs of legs.

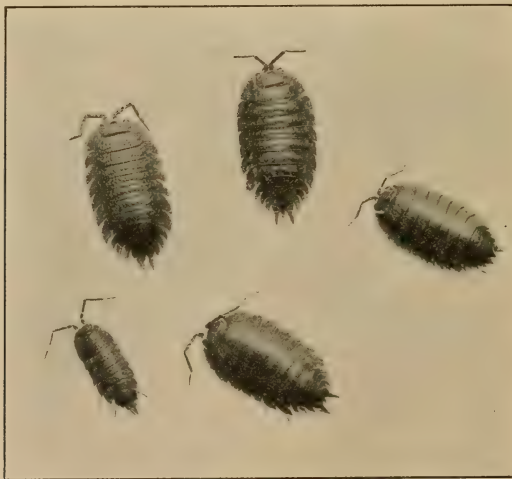


Fig. 1.—The dooryard sowbug, *Porcellio lævis* Koch. Enlarged twice. (Original)

The antennæ are 7-jointed. The length varies from one eighth inch for the very small young to over one half inch for the largest fullgrown specimens.

Life History.—The sowbugs are not aquatic, but are always found in wet or damp places, and therefore become especially abun-

¹A very closely related species, *Porcellio spinicornis* Say, is usually associated with this species in the central part of the state. Both species were determined by Miss Rathburn, U. S. Nat. Museum, through the kindness of Dr. L. O. Howard.

dant at times under thick vegetation in the garden, greenhouses, manure piles, cellars, under boards and around wells. There are no transformations in their development as in insects and the young appear very much like the fully matured forms, except in size and color. Until ready to feed the young are carried about in a receptacle formed by modified anal plates of the female. Feeding is done during the night and decayed vegetable matter forms the principal diet, but at times the roots and foliage of plants are attacked. There is probably but one generation a year, which begins in the spring.

Nature of Work.—As previously stated, roots and foliage are sometimes devoured, though there is little excepting the presence of the sowbugs themselves to name the marauder. The caps of mushrooms are often attacked when quite young and small holes eaten into them, or they may be entirely destroyed.²

Distribution.—This species is widely distributed throughout the State and country.

Food Plants.—Though normally of little consequence to growing vegetation, many plants growing in greenhouses or in damp favorable localities may be attacked. Mushrooms are recorded as food.² Prof. W. E. Collinge reports it as often destructive to the roots of strawberries.³

Control.—In greenhouses the best remedy is a thorough fumigation with hydrocyanic acid gas at the rate of $\frac{1}{2}$ oz. cyanide to every 100 cubic feet of air space. If the greenhouse is very tight the cyanide should be reduced to $\frac{1}{4}$ oz. to avoid burning to tender foliage. Slices of raw potatoes,⁴ carrots or other vegetables rolled in Paris green and placed in the haunts of this pest will prove effective in the greenhouse, as well as in the garden, cellar or other places.

²Popenoe, C. H., Cir. No. 155, Bur. Ent., U. S. Dept. Agric., p. 8, 1912.

³Jr. Bd. of Agric., Vol. XXI, No. 3, p. 210, June, 1914.

⁴Popenoe, C. H., Cir. No. 155, Bur. Ent., U. S. Dept. Agric., p. 9, 1912.

ARACHNIDA (Class)

SCORPIONS, SPIDERS AND MITES

Because of their economic importance, we have thought it best to include here the common injurious mites of California, even though they are not insects. As pointed out in the general classification, mites usually have eight legs and have the head and thorax united. Some species, however, especially the blister-mites, have only four legs, while the young red spiders have six legs until after the first molt.

All forms feed by piercing the plant tissues and extracting the juice. They multiply very rapidly and are thus capable of much damage.

The winters are passed in either the adult or egg stages under the scales of the bark, on the small limbs, around the buds or under the bud scales. As soon as the first leaves appear in the spring the mites begin work. The eggs are laid singly on the outside or inside of the plant tissues, or in clusters upon the bark; in the latter case they may be deposited around the buds, some time before these begin to open. The young develop very rapidly and are soon capable of bringing forth new broods. The breeding continues throughout the summer—the greatest number of mites being evident during the hottest and driest weather. Cold, damp weather seems to retard all activities.



Fig. 2.—A scorpion, *Vejovis boreus* Girard, which is found in the southern part of the State. (Original)

THE RUST MITE OF THE ORANGE AND THE SILVER MITE OF THE LEMON

Eriophyes oleivorus (Ashmead) (Family Eriophyidae)

(*Phytoptus oleivorus* Ashmead)

(Figs. 3, 4)

Description.—The adult mites are so small as to be invisible except with the aid of a lens. They are light yellow in color, long and pointed anteriorly, with two pairs of legs near the head. The eggs are exceedingly small, circular and faintly yellow in color. The presence of the mite is easily told by the characteristic silvery chafing of the skin of the lemon, due to the destruction of the oil cells. In Florida the oranges are also chafed, causing a russetting.

Life History.—The eggs are deposited singly or in small clusters on the leaves or fruit. They hatch in less than a week in hot weather, but require twice as long in cold weather. After several molts the

mites become full grown in from two to three weeks. The young and adults feed upon the oil in the succulent parts of citrus plants, which is obtained by piercing the oil cells with their beaks. The adults are capable of rapid locomotion and move freely. They breed from spring until late fall, giving rise to many overlapping broods each year.

Nature of Work.—On the bark of the limbs, the leaves, and the rind of the fruit there is produced a silvery of the tissues which also become decidedly hardened, and which is very easily distinguished after one becomes familiar with the work. In Florida this mite produces a russetting of the oranges and is called the rust mite. It has never attacked the orange in this manner in California and seems to confine its attacks entirely to the lemon.

Distribution.—Though this mite was introduced into San Diego County in 1889, it has spread very little, and is still confined to the extreme southern part of the State.

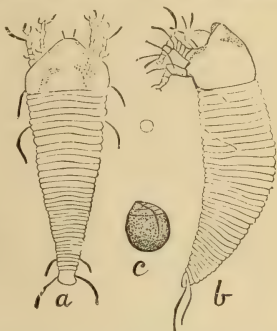


Fig. 3.—The rust mite of the orange or the silver mite of the lemon, *Eriophyes oleivorus* (Ashm.). Greatly enlarged. (After Hubbard, U. S. Dept. Agric.)

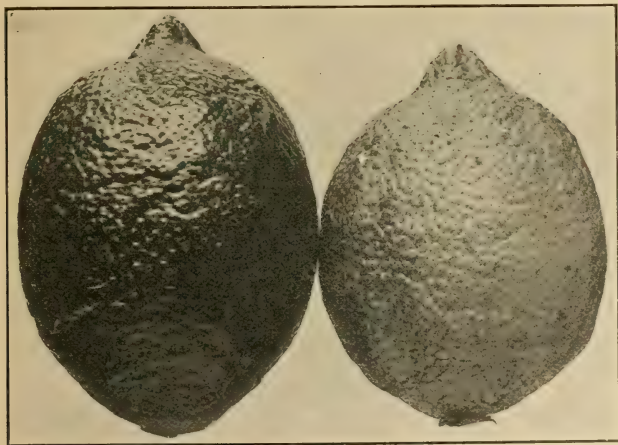


Fig. 4.—Lemon on the right shows the work of the silver mite of the lemon, *Eriophyes oleivorus* (Ashm.). (After Quayle, Cal. Agrcl. Exp. Sta.)

Food Plants.—The mite works upon bark, foliage and fruit of lemon and orange trees. In California its attacks are usually confined to the lemon.

Control.—The remedies are the same as for the citrus red spider (*Tetranychus mytilaspidis*).

THE PEAR-LEAF BLISTER-MITE

Eriophyes pyri (Pagenstecher) (Family Eriophyidæ)*(Phytoptus pyri* Pagenstecher)

(Figs. 5, 8)

Description.—The work of this mite makes its presence easily distinguishable from all others. Pear leaves are so affected as to produce reddish or dark brown spots which become darker with age and may spread so as to entirely cover and destroy the foliage. On the apple the galls remain the color of the leaves. The younger shoots suffer most. The mites are very minute and can be seen only with the aid of a microscope. The body is elongated, transversely ribbed, transparent and has but two pairs of legs near the head.

Life History.—The mites pass the winter on the trees under the bud scales and begin to work upon the leaves just as soon as the buds begin to open in February. The eggs are deposited in the tissues of the leaves, and the feeding of the young causes the small characteristic swellings so often seen upon the foliage. Their work continues throughout the summer, there being several generations a year.



Fig. 5.—Work of the pear-leaf blister-mite, *Eriophyes pyri* (Pgst.), on fruit and leaves of pear. The picture of the fruit is slightly enlarged and that of the leaves reduced. (Original)

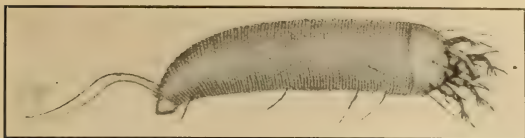


Fig. 6.—The pear-leaf blister-mite, *Eriophyes pyri* (Pgst.). Side view, greatly enlarged. (After Nalepa from Parrott)

Nature of Work.—The work of this mite is exceedingly characteristic and may be recognized at once by the illustration in Fig. 5. Small light green and reddish swellings or galls are first produced upon the leaves. These later turn black. Upon the fruit small, nearly circular marks of yellow, red or brown are produced, resembling a slight attack of scab. The work upon the fruit is usually done before it is one third



Fig. 7.—Apple leaf showing the work of the pear-leaf blister-mite, *Eriophyes pyri* (Pgst.). Enlarged twice. (Original)

grown, but the marks may grow with the fruit and injure it for market purposes other than for drying and canning. Upon young trees much damage is sometimes done, as the tender shoots are often stunted by the mites. On the foliage of the pear the galls are usually

made along the sides of the midribs of the leaves, while the base and margins of the apple leaves are preferred. It is not uncommon to find the entire surface of the leaves of both the pear and apple entirely covered with the galls.

Distribution.—This is a very common mite throughout the pear-growing districts of the State. It is very abundant in the interior valleys and the fruit districts of the Sierra foothills.

Food Plants.—The pear and apple are seriously attacked, the mites working upon the leaves, stems of the leaves and fruit, and also upon the fruit. The other plants recorded as hosts are European mountain ash, shadbush and the cotoneaster.

Control.—The control of this mite is becoming quite an important factor in the raising of pears, especially in the Sierra foothills in Placer, Nevada and El Dorado counties. Many of the sulphur preparations, as pure flowers of sulphur, flowers of sulphur and hydrated lime, lime-sulphur and atomic or milled sulphur have been used. The commercial lime-sulphur (1-13) has given very good results. Atomic



Fig. 8.—Buds of pear tree in good condition to spray for the pear-leaf blister-mite, *Eriophyes pyri* (Pgst.). Natural size. (Original)

sulphur has not been thoroughly tried out, but judging from its efficiency in controlling other mites it is also suitable for this one. The most important consideration is the time of application, which should be made in February, just as the buds are opening, as shown in Fig. 8. At this time the hibernating adults are moving to the young leaves to lay eggs, and a spraying at that time will kill nearly all of them. Mr. J. E. Hassler, Horticultural Commissioner, fully demonstrated this in El Dorado County in the spring of 1914, and it has also proven reliable in other places.

THE WALNUT BLISTER-MITE³*Eriophyes tristriatus* Nalepa (Family Eriophyidæ)

(Figs. 9, 10)

Description.—The adults resemble in a general way the other members of this genus, being very minute, enlarged at one end and nearly pointed at the other, light greenish white and with but two pairs of legs. The blisters made by this mite are very characteristic. On the leaves of the English walnut they are in the form of thickened felt-like pads usually lighter in color, producing swellings on the upper and depressions on the lower surfaces. On the leaves of the wild black walnut, however, the blisters are smaller in area but decidedly gall-like, as shown in Fig. 10.

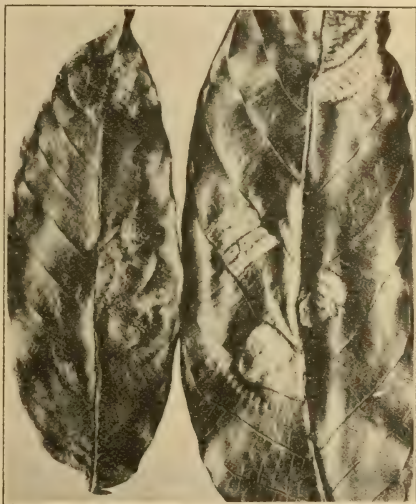


Fig. 9.—Leaves of the English walnut showing light-colored felt-like blisters caused by the walnut blister-mite, *Eriophyes tristriatus* Nalepa. Natural size. (Original)

Life History.—Little is known of the life history of this mite. Probably hibernation takes place under the scales of the leaf buds, as in the case of the pear-leaf blister-mite, but this has not been proven. The mites appear with the leaves and at once begin

to work upon the undersides of them, causing the felt-like blisters, which gradually enlarge as the number of mites increases.

Nature of Work.—The illustrations (Figs. 9 and 10) show well the nature of the work. Though often a source of annoyance, the attacks are not extensive enough to cause any particular injury to the trees.

Distribution.—The walnut blister-mite is exceedingly common throughout the State.

Food Plants.—The leaves of the wild black walnut and the English walnut are attacked.

Control.—Injuries by this mite are not at all severe and have not warranted control measures in the past. However, if such are deemed necessary, those recommended for the pear-leaf blister-mite may be used. The time of application of the sprays would be just as the leaf

³Determined by Nathan Banks who also records a variety (*erineus* Nalepa) of the above species which causes reddish blisters on the walnut leaves instead of the light-colored ones.



Fig. 10.—Leaves of the California black walnut showing gall-like blisters produced by the walnut blister-mite, *Eriophyes tristriatus* Nalepa. Natural size. (Original)

buds are beginning to open. Late applications after the blisters are formed would be useless, as the mites are hidden and protected by the felt-like pads.

ERINOSE OF THE VINE

Eriophyes vitis Landois (Family Eriophyidae)

(Fig. 11)

Description.—The mites are silvery white or light yellow, somewhat cone-shaped with head end largest and tapering to a point at the tail. The body is encircled with many fine lines and the two pairs of legs are close to the head. They are exceedingly small and can be seen only with keen eyes or with the aid of a magnifying glass. The work is very characteristic, consisting of thickened felt-like pads made on the undersides of the leaves, causing a swelling on the upper and a depression on the lower surfaces of the leaves. Beneath the felt-like pads are first very light green, but they eventually become dark brown.

Life History.—The place of hibernation of the mites has been problematic to some, but from the nature of early treatments, which consisted in drenching the trunks of the vines during the winter, they must conceal themselves in cracks or under the bark or under the

scales of the buds. They appear in the spring as soon as the buds open and begin to work upon the undersides of the young leaves. The blisters are gradually enlarged until they often cover the entire under surface.



Fig. 11.—Erinose produced on grape leaf by *Eriophyes vitis* Landois. The discolored areas are dark brown or black. Natural size. (Original)

Nature of Work.—The felt-like swellings have already been described. They are well illustrated in Fig. 11. Severe infestations sometimes result in the killing of the leaves and a corresponding weakening of the vines.

Distribution.—The erinose mite occurs throughout the grape-growing districts of the State. It was probably imported from Europe.

Food Plants.—The foliage of many varieties of grapes is attacked, but a few are apparently immune and quite a number are only slightly infested.

Control.—Sulphuring the vines early in the spring, soon after the buds open, or as ordinarily applied for mildew, is usually sufficient to hold this mite in complete subjection.

THE PEAR-LEAF RUST MITE

Epitrimerus pyri Nalepa (Family Eriophyidæ)

(Figs. 12, 13)

Description.—The mites are so small that they cannot be seen singly without the aid of a hand lens. When fully matured they are pale yellowish and, according to Nalepa, the females are about $\frac{1}{100}$ inch and the males $\frac{1}{200}$ inch long. The body is nearly triangular in shape, being broadest near the head, tapering nearly to a point at the tail, which supports two rather long caudal setæ. The entire body is encircled with numerous transverse bands, as shown in Fig. 13. There are two pairs of legs near the head.

Life History. — Very little is known of the life history of this mite. It apparently passes the winter in the bud scales, much as does the pear-leaf blister-mite, and begins to work upon the leaves as soon as the buds open in the spring. By the middle of June it becomes plentiful and often quite destructive, sometimes defoliating trees to quite an extent.

Nature of Work. — In feeding this mite chafes the under epidermis of the leaf, causing a rusty discoloration which is very characteristic. The leaves are also curled by the attacks of the mite. This russetting is the only clue to its existence in an orchard. With a hand lens and some pains they may be seen sometimes as tiny objects either stationary or moving about very slowly.

Distribution. — This pest was first discovered in California by Mr. Geo. P. Weldon, who took specimens in San Diego, Sonoma and Contra Costa counties in 1913.

Since then he has found it in Modoc, Yolo, San Joaquin and Fresno counties and the writer has received it from San Luis Obispo County, thus indicating its very general distribution throughout the State.

Food Plants. — The pear appears to be the preferred host of this mite, though the peach and occasionally the apple are attacked.

Control. — Control measures are the same as for the pear-leaf blister-mite.



Fig. 12.—Pear leaf showing discolored edges produced by the pear-leaf rust mite, *Epitrimerus pyri* Nalepa. Slightly enlarged. (Original)

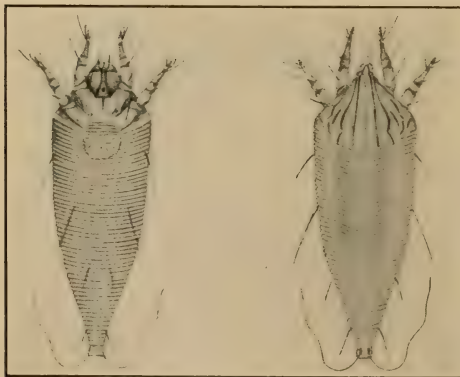


Fig. 13.—The pear-leaf rust mite, *Epitrimerus pyri* Nalepa. Ventral and dorsal views. (After Nalepa from Parrott)

THE RED SPIDER^o*Bryobia pratensis* Garman (Family Tetranychidæ)

(Figs. 14, 15)

Description.—The young mites are red, becoming brown when fully developed. Though very much smaller than a pinhead, this species is much larger than any of the common so-called "red spiders" in the State. The eggs are red, globular and so small as to be scarcely visible to the unaided eye (Fig. 14). This species is easily distinguished by the small marginal plates around the edges of the body, which may be seen under a compound microscope, as shown in Fig. 15.

Life History.—The eggs, deposited in the fall, hatch with the first warm weather in the spring and the mites at once begin to work. Their development is very rapid and power of reproduction exceedingly great, so by summer there are often sufficient numbers to do



Fig. 14.—Eggs of the red spider, *Bryobia pratensis* Garman, on almond twigs. Greatly enlarged. (Original)

much damage. Breeding and feeding continue until fall, when the over-wintering eggs are laid and operations suspended until these hatch in the following spring.

^oThis species is also known as the brown, clover and almond mite.

Nature of Work.—The mites, in feeding, produce a fine yellow mottling effect upon the leaves, eventually causing them to turn yellow and to drop prematurely.

Food Plants.—This mite is an omnivorous feeder and may be found upon a great variety of plants. Alfalfa, clover and peas are severely injured, while almond, apple, apricot, barley, buckwheat, cherry, grasses, oats, peach, plum, prune, quince and wheat are also among the food plants.

Control.—Several important experiments have been carried on in the State to insure a more perfect control of this mite. A spray composed of lime-sulphur 4 gallons, flour paste 4 gallons, iron sulphate 2 pounds and 100 gallons of water has been recommended by Mr. W. H. Volek as reliable. The flour paste and lime-sulphur are thoroughly mixed in the spray tank, after which the iron sulphate is added and all thoroughly agitated while being applied. Later experiments with atomic sulphur applied at the rate of 10 pounds to 100 gallons of water have given excellent killing results, according to the observations made in commercial tests by Mr. Geo. P. Weldon, Chief Deputy State Commissioner of Horticulture. One great advantage in the use of the atomic sulphur is that it does not burn the foliage and can be used at almost any strength. A dormant spray of lime-sulphur, 1-10, is also valuable.

Natural Enemies.—The larvæ of the minute black ladybird beetles (*Stethorus vagans* Blackb. and *Stethorus picipes* Casey) and the green lacewing (*Chrysopa californica* Coq.) prey on the clover mite, but they do not appear to be important factors in keeping it in check.

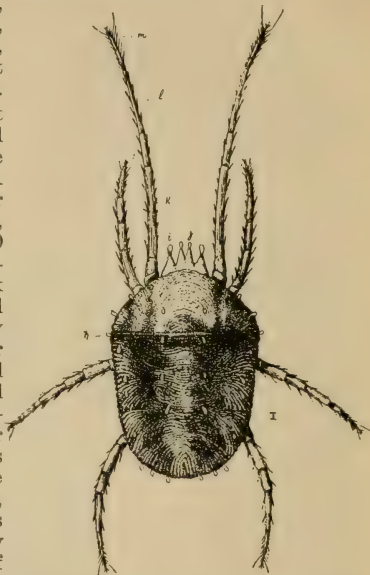


Fig. 15.—The red spider, *Bryobia pratensis* Garman. Adult very greatly enlarged. (After Riley and Marlatt, U. S. Dept. Agric.)

THE CITRUS RED SPIDER¹

Tetranychus mytilaspidis Riley (Family Tetranychidæ)

(Fig. 16)

Description.—The adult insects are cardinal red and scarcely larger than a pin point. They often occur so abundantly as to give the fruit and foliage a red color. The eggs are globular and red, as are also the younger stages.

¹This species is easily distinguished from the two-spotted mite by the small tubercles at the bases of the spines on the back.

Life History.—The eggs are suspended upon minute stalks with threads as supports. They hatch in from nine to twelve days, being laid from May on throughout the warm summer months. The first born are six-legged, but after the first molt acquire another pair, making the usual number. In two weeks they are full grown and begin egg-laying. They live from thirty to thirty-five days, thus making the life cycle cover a period of about six weeks. By far the greater numbers occur during the warm summer months, when most of the damage is done, but much damage often occurs until late in winter. On deciduous fruit trees the eggs are deposited at the bases of the last year's shoots and do not hatch until the following spring.

Nature of Work.—This mite besides producing the whitish mottled effect upon the leaves also causes similar markings upon the fruit.

Distribution.—The citrus red spider occurs throughout the State. It is very common in the southern part and was taken in Humboldt County in 1914 by Geo. P. Weldon, where he found it upon apple trees.



Fig. 16.—The citrus red spider, *Tetranychus mytilaspidis* Riley. Greatly enlarged to show tubercles at the bases of the spines on the back. (After Volck, Cal. Agrcl. Exp. Sta.)

Food Plants.—Though primarily a citrus pest, attacking the citron, grapefruit, lemon, orange, tangerine, etc., it also feeds upon the foliage of the apple, peach, pear, prune and other deciduous fruit trees.

Control.—As in the case of other mites, much experimental work has been directed against this species, particularly in the citrus orchards of both the northern and southern parts of the State. A two and two and one half per cent solution of commercial lime-sulphur have been used in the past with very good results, except in hot, dry weather, when some burnings have resulted. The addition of four gallons of flour paste to 100 gallons of the above spray has been found by J. D. Neuls⁸ to make this spray much more efficient by spreading it more evenly upon the surface of the leaves and fruit and preventing

⁸Mo. Bul. Cal. Hort. Com. II, 557, 1913.

the spotting by the lime-sulphur, as often happens when the latter is used alone.

Natural Enemies.⁹—Natural enemies play a very important part in the control of this mite. Not all are recorded and the following are only the more important ones: The ladybird beetles (*Stethorus picipes* Casey, *S. vagans*, Blackb., *Psyllobora tædata* Lec.), the ashy gray ladybird beetle (*Olla abdominalis* Say), a staphylinid beetle (*Oligota oviformis* Casey), a thrips (*Scolothrips sexmaculatus* Pergande), the larvæ of a cecidomyid fly (*Arthrocnodax occidentalis* Felt), the dark triphleps (*Triphleps tristicolor* White), the larvæ of the green lacewing (*Chrysopa californica* Coq.) and the larvæ of the brown lacewings (*Hemerobius pacificus* Banks and *Symphorobius angustus* Banks) and larvæ of *Coniopteryx vicina* Banks.

THE TWO-SPOTTED MITE¹⁰

Tetranychus telarius Linnæus (Family Tetranychidæ)

(*Tetranychus bimaculatus* Harvey)

(*Tetranychus sexmaculatus* Riley)

Description.—This species, like the other mites, is exceedingly small, and individuals are seldom noticed excepting when they collect in great numbers. The color is red with a yellowish tinge and sometimes with two darker spots on each side of the body. The young greatly resemble the adults, but have six rather than eight legs.

Life History.—The mites usually begin to appear after the first warm weather in the spring, the winter having been spent in concealment. They spin threads, so as to hide themselves, their eggs and young, on the undersides of the leaves and feed directly upon the tissues of the plant, by sucking which gradually stunts and kills the latter. The common red mite is a serious greenhouse pest, where, under favorable conditions, it is able to work throughout the entire year.

Nature of Work.—The work is practically the same as that of the red spider.

Distribution.—This mite is thoroughly distributed over the entire State and is met alike in field and greenhouse.

Food Plants.—This species is a very general feeder and may be found upon any of the following plants and undoubtedly many not herein listed: abutilon, almond, apple, arborvitæ, ash, aster, castor bean, bean, wild blackberry, sugar beet, birch, *Bouvardia*, calla, carnation, celery, cherry, chrysanthemum, citron, clematis, corn, cotton, cowpea, cucumber, currant, dahlia, eggplant, elm, fuchsia, geranium, gooseberry, grapefruit, heliotrope, hemp, hop, hop-tree, horse-chestnut, iron-weed, jimpson weed, lemon, easter lily, *Manettia*, maple, mignonne, monkey flower, moonflower, morning-glory, muskmelon, okra, orange, passion vine, pea, peanut, peach, pear, pecan, pepper, phlox, pink, plum, poplar, prune, pumpkin, raspberry, rose, sage, smilax,

⁹Quayle, H. J., Bul. 234, Cal. Agrcl. Exp. Sta., pp. 505-519, 1912.

¹⁰This species is also known as the six-spotted mite.

squash, strawberry, sunflower, *Thunbergia*, tomato, verbena, violet, English and black walnut, watermelon and various weeds.

Control.—Control measures are the same as for the red spider.

An experiment with atomic sulphur in the Fair Oaks section of Sacramento County in the month of July, 1914, is reported by Mr. G. P. Weldon to be exceedingly satisfactory. The following proportions were used:

Atomic sulphur	10 pounds
Water	100 gallons

From ninety-five to ninety-eight per cent of the mites were killed with a single application and no damage was done to the foliage or fruit.

Natural Enemies.—The small ladybird beetles (*Stethorus vagans* Blackb., *S. picipes* Casey, *Scymnus marginicollis* Mann., *S. nanus* Lec.), the larvæ of the green lacewing (*Chrysopa californica* Coq.), the dark Triphleps (*Triphleps tricolor* White) and many other insects prey upon this species.

DIPLOPODA (Class)

THOUSAND-LEGGED WORMS

These so-called "worms" are easily recognized by their cylindrical or semi-cylindrical bodies, which are rather hard and made up of a large number of joints. The antennæ are short and there are two pairs of short legs to each segment of the body. The mouth parts are not adapted for biting any hard object, as they are provided with a series of combs, by means of which they comb or scrape off soft decaying organic matter.

THE COMMON MILLIPED

Julus hesperus Chamberlin¹¹

(Fig. 17)

Description.—The mature millipeds are of a rich chestnut brown color, often nearly black, and average about one half inch in length. The immature forms appear the same as the adults, except in size and lighter color.

Life History.—Very little is known concerning the life history of these animals. They usually live in damp places in decayed vegetable matter, upon which they feed. Occasionally, however, they are found in plants near or in living tissue. Whether the initial injury is caused by the millipeds or some other animal has not been definitely proven. Dr. Chamberlin informs us that the mouth parts do not admit of biting hard materials, but are constructed more for scraping. There is probably a single generation a year, which starts in the spring.

Nature of Work.—The exact amount of damage done by these millipeds is only a matter of conjecture. However, as they are usually to be found present in all cases where they might be suspected,



Fig. 17.—The common millipede, *Julus hesperus* Chamb., in a head of lettuce. Natural size. (Photo by Leroy Childs)

¹¹Determined by Dr. R. V. Chamberlin, Dept. of Zoology, Harvard University, Can., Ent. XLVI, pp. 314-315, 1914.

they usually get the blame for any damage done. In lettuce the roots and heart are destroyed.

Food.—Specimens of this particular species have been received in heads of lettuce where it then appeared to have entered the roots and worked into the heart, as shown by the photograph (Fig. 17). An attack by a related species (*J. virgatus* Wood), on lettuce plants, especially the outside leaves near the main stalk, was reported in Ohio a number of years ago.¹² Potatoes, partially decayed and full of these millipeds, have been received from various parts of the State. We also note a similar condition reported in Dakota, 1889.¹³ Dr. R. V. Chamberlin reports that a species, *Julus lurcus* Meinert, is frequently found in cabbage heads in Europe and *Julus cæruleocinctus* Wood damages the fruits and roots of strawberries in the Eastern states. From what information we now have at hand it is evident that the species in question does infest plants under certain conditions, but until further data are furnished it should not be said that perfectly sound and healthy tissues are devoured to any great extent.

Control.—If it is a fact that root crops, like potatoes, are eaten a convenient method of control would be to slice the potatoes, roll them in Paris green and place them about in the places where the infestations occur.

¹²Insect Life, IV, p. 400, 1892.

¹³Insect Life, I, p. 316, 1889.

SYMPHYLA (Class)¹⁴

SYMPHYLIDS

"The members of this class are small and slender with soft, whitish integument and are more or less thysanuroid in appearance. Most of the segments bear a single pair of legs and none bear two pairs. Only twelve pairs are present in the adults and fewer pairs in the immature stages. No eyes or poison jaws are present. The antennæ are long and many jointed. At the caudal end of the body there is borne a pair of conspicuous styliform processes or cerci. The reproductive organs open in the anterior portion of the trunk, as in the diplopods. One species in California has proven quite destructive to certain forms of vegetable life and is dealt with separately. No such habits are known for any member of the class elsewhere."

THE LIMA BEAN SYMPHYLID

Scutigera californica (Woodworth)¹⁵

(*Scolopendrella californica* Woodworth)

(Figs. 18-20)

Description.—The full-grown symphylids are pure white in color and exceedingly small, varying from one fourth inch to nearly one half inch in length. There are twelve pairs of legs, the last two pairs being longer than the rest. The anal appendages are slightly shorter than the last body segment. There are fewer legs in the immature forms.

Life History.—The life history of this species is not well known. Normally it evidently feeds upon decayed vegetable matter, but in the spring it attacks planted seeds and vegetables, often doing much damage to the former by preventing healthy germination and growth of the young plants. Mr. E. R. Ong found very young forms in the decaying stubs of asparagus stalks beneath the hard outer skin, in February and March, 1912. There is apparently but one brood a year—the young appearing very early in the spring.

Nature of Work.—The work of this symphylid is very marked and consists in the making of numerous small tunnels through the host, as shown in Fig. 19. This work is done before the plant comes to the surface of the ground.

Distribution.—The animal is distributed throughout the State, but has proven to be a pest only in the central and southern parts.

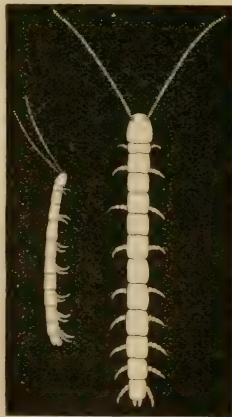


Fig. 18.—The lima bean symphylid, *Scutigera californica* (Woodw.). Greatly enlarged. (After Woodworth)

¹⁴Written by Dr. R. V. Chamberlin, Harvard University, Cambridge, Mass.

¹⁵This species is reported by Dr. R. V. Chamberlin as being apparently synonymous with or extremely close to *Scutigera immaculata* (Newport).

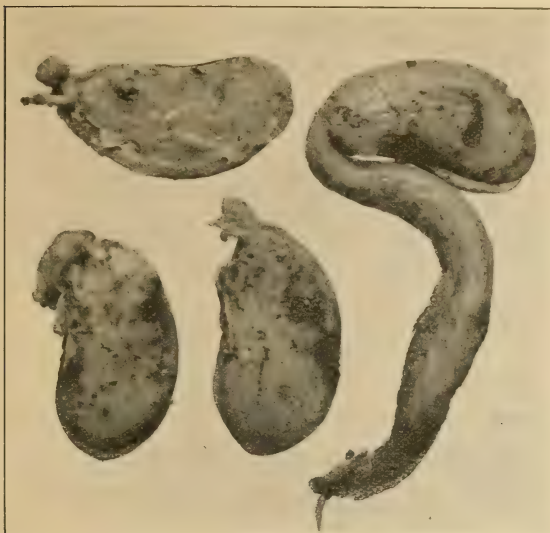


Fig. 19.—Lima beans showing the work of the lima bean symphyliid, *Scutigerella californica* (Woodw.). Enlarged twice. (Original)

Food Plants.—The tender shoots of asparagus and morning-glory before they come to the surface of the ground and the germinating seeds of lima beans and peas are hosts. Mr. E. R. Ong also found it attacking the fleshy roots of wild mustard and radish.

Control.—Inasmuch as but comparatively few crops are injured by this pest, a rotation of crops may be a means of controlling it. Bare fallow may even be necessary to accomplish the desired destruction of the pest.

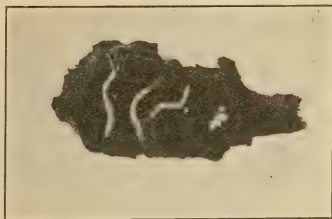


Fig. 20.—The lima bean symphyliid, *Scutigerella californica* (Woodw.). Enlarged twice. (Original)

CHILOPODA (Class)

CENTIPEDES

The members of this class are long and slender with rather soft, flattened bodies, made up of many segments. The antennæ and legs are quite long—much longer than in the case of the millipeds, and the legs are attached wide apart at the sides of the body, rather than close together on the ventral surface, as in the diplopods. There is but one pair of legs to a segment. The centipedes are carnivorous in habits and feed upon such other small animals as may be captured. Some species are quite large and have the first pair of legs modified into poison-jaws, so that their bites are quite poisonous. From their carnivorous habits they might in general be classed as beneficial, in that they destroy many injurious insects and other small animals.

THE HOUSE CENTIPEDE¹⁰

Scutigera forceps Raf.

(Fig. 21)

Description.—The illustration, Fig. 21, shows well the general appearance of this centipede. The body is about 1 inch long and grayish yellow marked on the back with three longitudinal dark stripes. The antennæ are longer than the body and very slender. There are fifteen pairs of long slender legs in the adults and less in the young. The last pair are much longer than the rest and in the females twice as long as the body. The entire animal is exceedingly frail, and it is practically impossible to capture one without removing some of the delicate legs.

Life History.—Practically nothing is known about the life history of this centipede. It may be found in the adult stage nearly any part of the year. The writer captured an adult specimen in January. It is carnivorous in habits and feeds upon many of the common household pests and in this sense may be considered beneficial. Though the centipede is claimed to have bitten people, nothing definite has ever been recorded, and it is doubtful if the animal is able to inflict a wound that would be very serious, and then only if caught or partially crushed and in self-defense. It travels exceedingly rapidly and is very difficult to capture. In the houses it may dart across the floor, walls or even one's hand, causing a very unpleasant sensation to any one seeing or feeling it.

Distribution.—Professor R. V. Chamberlin has taken this centipede in Butte, Fresno, Santa Barbara and Los Angeles counties. The writer has collected it at Sacramento.

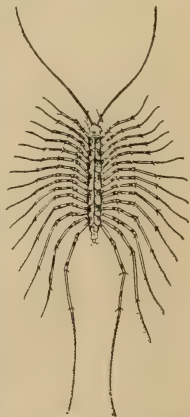


Fig. 21.—The house centipede, *Scutigera forceps* Raf. Natural size. (After U. S. Department Agric.)

¹⁰Marlatt, C. L., Cir. No. 48, Bur. Ent. U. S. Dept. Agric., 1908.

Hosts.—Cockroaches, houseflies, clothes moths and other insects are said to be devoured by it. Some have thought that it injured clothing, but there can be no possibility of its destroying fabrics, as its mouth-parts would hardly permit of such work.

Control.—Because of the scarcity of the centipede, control measures will not be necessary, unless there is a decided increase in the future. As the breeding places are unknown, all that can be done is to kill all that are seen.

INSECTA OR HEXAPODA (Class)

INSECTS

ORDERS

The following study is based on the order as a unit of arrangement instead of the food plant, as is so often the case of works on economic entomology. This is done with the desire of avoiding the constant mixing of insects belonging to different orders, families and genera, to prevent repetitions, to give a more comprehensive idea of the relationships of insects and the corresponding relations of control measures.

The orders are arranged in chronological sequence, beginning with those first appearing in the oldest fossils. The arrangement is the one used by Prof. C. W. Woodworth, except that the *Thysanoptera* are placed in a separate order and not along with the *Hemiptera*.

1. **Aptera**.—Silver-fishes, silver-moths, spring-tails, bristle-tails, etc.
(†Symphleona, *Thysanura, †Machiloidea, †Dicellura, †Rhabdura, †Protura.)
2. **Neuroptera**.—Lacewings, ant-lions, caddis-flies, scorpion-flies, etc.
(†Rhapidoidea, †Megaloptera, *Mecoptera, *Trichoptera, *Plecoptera.)
3. **Odonata**.—Dragon-flies.
4. **Ephemera**.—May-flies.
5. **Corrodentia**.¹⁷—White-ants, psocids, book-lice, bird-lice, etc.
(*Isoptera, †Embioptera, Mallophaga.)
6. **Orthoptera**.—Cockroaches, earwigs, walking-sticks, mantids, crickets, katydids, grasshoppers.
(†Zoraptera, †Mantoidea, †Phasmoidea, †Blattoidea, †Diploglossata, *Euplexoptera.)
7. **Thysanoptera**.—Thrips.
8. **Hemiptera**.—Cicadas, lantern-flies, spittle insects, leaf-hoppers, tree-hoppers, jumping plant lice, plant lice, scale insects, white flies and bugs.
9. **Coleoptera**.—Beetles.
(†Acreioptera, †Strepsiptera.)
10. **Diptera**.—Flies and fleas.
(†Homaloptera, *Siphonaptera.)
11. **Hymenoptera**.—Horntails, sawflies, wasps, bees, ants, etc.
12. **Lepidoptera**.—Moths and butterflies.

†Groups or orders not largely accepted.

*Additional orders frequently used by other authors.

¹⁷*Mallophaga* and *Corrodentia* are considered separate orders by Comstock and Kellogg and as suborders of *Platyptera* by Folsom.

NEUROPTERA (Order)

LACE OR NERVE-WINGED INSECTS

LACEWINGS, ANT-LIONS, CADDIS-FLIES, SCORPION-FLIES, ETC.

The members of this order have quite large membranous wings with lace-like veins. They have complete metamorphoses, the larvæ being entirely different from the pupæ and adults. The mouth-parts are for biting. Many of them are beneficial, being predaceous on injurious insects.

The larvæ of many of the families are aquatic in habits, but the adults of all species live in the air and upon the land.

The most important and beneficial family is the *Chrysopidæ*, but the *Hemerobiidæ*, *Raphidiidæ* and *Myrmeleonidæ* are efficient destroyers of many injurious insects.

THE GREEN LACEWING

Chrysopa californica Coquillett (Family Chrysopidæ)

(Fig. 22)

Description.—The adult form is well known to all by its delicate green lace wings and long hair-like antennæ. The body is also green with a longitudinal yellow stripe extending the full length of the dorsum, which distinguishes this species from all others. The eggs are oblong, pearly-white and attached to fine stalks, which suspend them nearly one half inch in the air. The young vary from $\frac{1}{8}$ to nearly $\frac{3}{4}$ inch in length, are yellow with reddish markings and characterized by long sickle-like jaws. The cocoons are globular and white, being fastened by supporting threads.

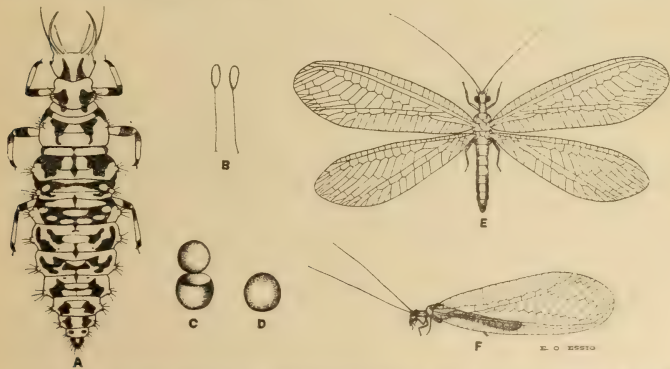


Fig. 22.—The green lacewing, *Chrysopa californica* Coq. A, larva; B, eggs; C, pupa case with lid open after adult has emerged; D, pupa case before emergence of adult; E, adult with wings spread; F, adult in natural position. (Author's illustration, P. C. Jr. Ent.)

Life History.—The eggs may be found in the orchards from late fall until spring and hatch with the first warm weather. The larvæ mature in about two weeks, and then spin a small circular cocoon in which to

pupate. In two weeks more the adults emerge. There are several broods a year. The adults and eggs may be found during the winter months in the southern part of the State, but in the colder portions only the eggs survive the winter.

Nature of Work.—The larvæ with their long sickle-like jaws extract the juices of small soft-bodied insects. They are very ravenous and consume quantities of both beneficial and destructive insects.

Distribution.—The green lacewing occurs abundantly throughout the entire State.

Hosts.—The larvæ prey on all soft-bodied insects, including plant lice, mealy bugs, young scales, larvæ of many beetles and on all of our common mites. They are also cannibalistic. They prey largely on insect pests, but often do great damage in destroying the larvæ of ladybird beetles. The pupal forms are preyed on by internal parasites, which prevent large numbers from maturing.

THE BROWN LACEWING

Symphorobius angustus Banks (Family Hemerobiidæ)

(Fig. 23)

Description.—The general appearance and shape are considerably like the well-known green lacewing, but the wings are not so slender. The ground color is brown with many darker blotches on the wings. The larvæ are dark gray or slate-colored with amber margins and, when full-grown, are nearly $\frac{3}{8}$ inch long.

Life History.—The eggs are deposited among or near suitable prey and hatch to slate-gray and tan-colored larvæ, which are very active, one very noticeable characteristic being the constant motion of the head when they are searching for food. When full-grown they are nearly $\frac{3}{8}$ inch long. The larvæ spin thick white cocoons in which to pupate. This requires but a few days or weeks, when the adults emerge.

Distribution.—The brown lacewing occurs throughout the central and southern parts of the State.

Hosts.—The larvæ feed on many soft-bodied insects, including plant lice and scales. It is a very efficient predator on the young of the citrus mealy bug, *Pseudococcus citri* (Risso).

Natural Enemies.—This insect would be far more useful if it were not in turn preyed upon by a hymenopterous parasite (*Isodromus iceryæ* How.), which destroys the pupæ in the cocoons. In not a few instances fifty to seventy-five per cent are parasitized.



Fig. 23.—Larva and adult of the brown lacewing, *Symphorobius angustus* Banks. Enlarged five times. (Author's illustration, P. C. Jr. Ent.)

THE LARGE RAPHIDIA

Raphidia oblita Hagen (Family Raphidiidae)

(Fig. 24)

Description.—The adults of this common species may be easily distinguished from other lace-winged insects by the long narrow neck or prothorax, which is always longer than wide. The body is black with reddish-brown markings on the head, thorax and with narrow bands of the same color around the abdomen at each joint. Each wing has a prominent black stigma on the front margin, near the tip. The antennæ are nearly as long as the body. The length of the body is slightly more than one half inch. From head to the tips of the folded wings the length is 11-16 inch.

Life History.—The life history of this insect is not well known. The larvæ live in the soil, among refuse and under the bark of trees, where they feed on various soft-bodied insects, especially the immature forms, as caterpillars, grubs, pupæ, etc. The adults live in the grass and are quite active on the wing. Like the larvæ, they are carnivorous and destroy many insects.

Hosts.—Among the hosts may be included almost all of the larvæ and pupæ of the smaller insects, especially those transforming in the ground or under trees. Those of the codlin-moth are recorded as being hosts of one of these insects.¹⁸

Distribution.—It is distributed throughout the State, but this species seems to be more abundant in the central part.



Fig. 24.—The large Raphidia, *Raphidia oblita* Hagen. Enlarged twice. (Original)

¹⁸Insect Life, III, p. 43, 1890.

CORRODENTIA (Order)

WHITE ANTS, PSOCIDS, BOOK-LICE, BIRD-LICE, ETC.

The members of this minor order have direct or incomplete metamorphoses, the larvæ and nymphs not varying greatly in structure from the adults. The wings, when present, are two pairs, membranous, delicate, equal or front wings slightly larger. This order was previously listed as *Platyptera* with the *Corrodentia* and *Mallophaga* as suborders. The latter is still retained as such, but will not be considered here. In fact, only the family *Termitidæ* is represented by one species in this work.

TERMITIDÆ (Family)

TERMITES OR WHITE ANTS

These insects, though commonly called white ants, are not ants at all, being more closely related to the lower groups of insects rather than to the true ants. Some entomologists have placed them in a single order—*Isoptera*.

The eyes of the termites are faceted or made up of many apparently individual eyes; antennæ 9-31 jointed; prothorax large and well developed; abdomen elongated with ten segments; wings long, slender, membranous, equal and delicate. The habits are social, there being workers, soldiers, and sexually mature males and females, or queens.

THE COMMON TERMITE

Termes lucifugus Rossi

(Fig. 25)

Description.—The workers of this species are rather small and well shown in Fig. 25. They are transparently white in color, the contents of the alimentary canal giving a yellowish or brownish cast. The head is darker yellow and mandibles brown. The soldier ants have large brown heads, comprising at least one third of their entire bodies. The queen ant is much larger than the other forms, while the males are small. It is claimed that there are no less than fifteen kinds of individuals in this species.

Life History.—These termites usually live in dead or decaying wood, but occasionally work in the living and growing tissues. They make very extensive galleries through all parts and thus often destroy buildings, fences, etc., as well as fruit trees. The queen gives rise to all the young, which appear in great numbers, especially during the summer months. In the fall or autumn winged or migratory forms appear and often fly by thousands on dark days and towards evening. In habits and life history they greatly resemble true ants and bees.



Fig. 25.—The common termite, *Termes lucifugus* Rossi on decaying roots of a nectarine tree. Natural size. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

Nature of Work.—As previously stated, these termites usually work upon dead or decaying wood, but then usually only in the presence of moisture. In the southern parts of the State these insects have often become destructive to fruit trees, working upon the roots underground and making galleries up the trunk. No doubt they usually begin to work in the decaying tissues, but often continue into the healthy portions of the tree.

Distribution.—This species may be found in almost every section of the State.

Food Plants.—The following trees are reported as being injured by the common termite: apricot, cherry, lemon, orange, peach and pear.

Control.—Due to their secluded work the damage is usually done before their presence is known and too late to effect a remedy. However, if close observations are made in infested districts and their work discovered, the colony may be almost entirely exterminated by the use of a liberal dose of carbon bisulfid applied in cotton or a sponge directly within their burrows or under the base of the tree.

ORTHOPTERA (Order)

STRAIGHT-WINGED INSECTS

COCKROACHES, EARWIGS, WALKING-STICKS, PRAYING MANTIDS, CRICKETS,
KATYDIDS AND GRASSHOPPERS

All of the members of this order, with the exception of the praying mantids and some of the earwigs and cockroaches, are destructive to vegetation and most of them are serious pests to cultivated crops. Though most of them possess four wings, a few genera and species have none at all. The fore wings are called tegmina and differ from those of most insects, in that they are leathery, being a means of protection for the delicate thin hind wings, which are used for flying. All the members have strong and well developed mouth-parts for biting and chewing. The metamorphosis or change from the young to the adult is gradual and scarcely noticeable. When born these insects always resemble the adult, with the exception that they have no wings and the sexual organs are undeveloped.

To follow out a systematic arrangement of this order, the families are arranged as follows:

1. *Blattidæ*
2. *Forficulidæ*¹⁹
3. *Phasmidæ*
4. *Mantidæ*
5. *Gryllidæ*
6. *Locustidæ*
7. *Acrididæ*

While the representatives of practically all of these families are of great interest and often of economic value, those of only the last three are deemed of sufficient importance to be included in a work of this character. These will be considered in the order as given above.

GRYLLIDÆ (Family)

CRICKETS

The members of this family, like the locustids, have long filiform antennæ, but the tarsi are three-jointed and the ovipositor, when strongly developed, is spear-shaped. Many of the species are wingless. When the wings are present they are deflexed on the outer edge and fold closely to the sides and back. It is also a musical family. Most of the species are injurious to vegetation.

The common field crickets are most abundant and familiar. They seldom do enough damage to deserve special treatment here. The tree-cricket are almost all arboreal in habits and do considerable damage to economic plants by making incisions in the smaller branches and stems in which the eggs are deposited.

¹⁹The *Forficulidæ* are placed in a separate order, *Euplexoptera*, by some entomologists.

THE CALIFORNIA TREE-CRICKET

Ecanthus californicus Walker

(Figs. 26, 27)

Description.—The adults are slightly more than $\frac{1}{2}$ inch long and are light yellow or very pale-green in color. The antennæ are long and hair-like, and the legs are very slender. The females appear narrow, because the wings are folded roof-like over the back, while the males appear broad, because the wings are spread flat on the back. They average from $\frac{3}{4}$ to 1 inch in length.

The eggs are pearly white, slender, curved and about $\frac{1}{8}$ inch long. They are inserted singly or in small scattered groups in the tissues of the host plant. The young are light green and appear like the adults, except that they are entirely wingless or have only wing pads.

Life History.—The eggs are inserted singly or in small loose clusters into the canes or twigs in the fall and remain dormant during the winter. The first warm spring days cause them to hatch, and the young, wingless, green crickets begin feeding on plant lice or other soft-bodied insects.

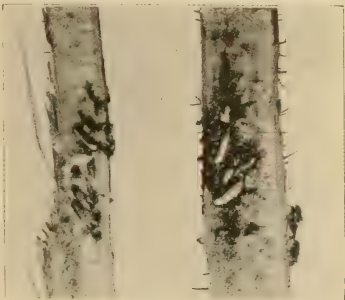


Fig. 26.—Eggs of the California tree-cricket, *Ecanthus californicus* Walk. In loganberry cane. Natural size. (Photo by Leroy Childs)

Throughout its entire life, from the time it leaves the egg until egg-laying commences in the fall, the insect is working for the benefit of the farmer. By autumn all forms are mature and egg-laying begins, the adults disappearing soon afterwards.

Distribution.—This is the common tree-cricket and occurs throughout the entire State.

Nature of Work and Hosts.—The damage done by the California tree-cricket is due almost entirely to its method of puncturing the small stems and canes of plants in egg-laying. It often happens that enough eggs are placed in the twigs to cause considerable loss. Raspberries, blackberries and loganberries receive the most injury, though young deciduous nursery stock is also often severely

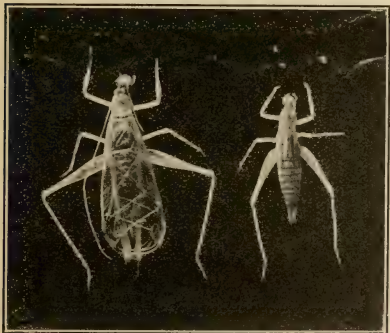


Fig. 27.—Adult male and nymph of the California tree-cricket, *Ecanthus californicus* Walk. Slightly enlarged. (Original)

injured. The feeding habits of this species place it among the beneficial insects and partially offset the damage done in depositing the eggs. The young and old alike feed on soft-bodied insects, principally plant lice, and due to their ravenous appetites they are able to consume great numbers of other injurious pests.

Control.—The method of eliminating subsequent broods and attacks consists in cutting out all canes showing the characteristic signs of having been punctured for egg-laying. It has been said by many reliable authorities that the good done by the tree-cricket in destroying injurious insects more than recompenses the farmer or fruit grower for the harm done and that only in rare cases should the eggs be destroyed, even after the injured canes or branches have been removed.

THE SNOWY TREE-CRICKET

Ecanthus niveus De Geer

Description.—The adult insect is slightly more than $\frac{1}{2}$ inch long and light yellow or greenish in color and appears much like the California tree cricket. The antennæ are very long and hair-like. There is one black dot on each of the two basal segments of the antennæ. The black-tipped ovipositor also helps to distinguish the female. The eggs are about $\frac{1}{8}$ inch long, slender, slightly curved and white. They are inserted in the stems of the host.

Life History.—The life history is not essentially different from that of the California tree-cricket.

Nature of Work.—The work of this species is practically the same as that of the California tree-cricket.

Distribution.—The distribution of the snowy tree-cricket is not well known. Mr. A. N. Caudell has received specimens from this State.

Food Plants.—The tree-crickets are usually predaceous in their feeding habits, but do however occasionally eat foliage. They never destroy enough foliage, however, to become injurious. The principal injury is in the method of egg-laying, as described under the California tree-cricket. According to P. J. Parrott,²⁰ the eggs of the snowy tree-cricket are deposited singly in the bark and not in compact rows, as has been the general belief. Apple, peach and plum are the preferred orchard hosts, while elm, willow and other trees are also attacked. In confinement eggs are laid in canes of the raspberry.

Control.—For control measures, see the same under the California tree-cricket.

LOCUSTIDÆ (Family)

THE LONG-HORNED GRASSHOPPERS

KATYDIDS

The members of this family are characterized by having long filiform antennæ, four-jointed tarsi and a six-pieced, flat, sickle-shaped or straight ovipositor. Many are pale or bright green, though a large number are quite dark. Many of them are great singers. The wings, when present, are usually large but thin and delicate. Practically all

²⁰Jr. Ec. Ent. IV, pp. 216-218, 1911.

of the species are vegetable feeders and while more or less destructive are not so much so as the short-horned grasshoppers (*Aceridiidae*).

The control of the members of this family is practically never attempted, but would be the same as for the short-horned grasshoppers.

THE LONG-LEGGED GRASSHOPPER

Clinoppleura melanoppleura (Scudder)²¹

(*Steioroxys melanoppleura* Scudder)

(Fig. 28)

Description.—The insect is one of the nearly wingless long-horned grasshoppers, the wings being reduced to mere pads on the back. The general color is light yellowish-brown with dark brown variations. The abdomen is slightly darkened on the sides and the outer surfaces of the hind femora are also dark. The lower portions of the pronotum are bright yellow and the legs are very long, the hind femora being over three times as long as the pronotum. The females are easily recognized by the straight ovipositor, which is abruptly pointed at the apex and is not as long as the posterior femora. The full-grown forms are from $1\frac{1}{4}$ to $1\frac{1}{2}$ inches long, exclusive of the ovipositor.



Fig. 28.—The long-legged grasshopper, *Clinoppleura melanoppleura* Scudd. Enlarged twice. (After Hunter, Cal. Agrcl. Exp. Sta.)

Life History.—The life history of this species is not well known, but is probably as follows: The females deposit their eggs in the late fall in or among various kinds of vegetation. The young, light-colored individuals hatch in the spring and begin feeding in the grassy fields and woodlands immediately after emergence and continue numerous

²¹*Clinoppleura melanoppleura* var. *infusca* Caudell is smaller and darker than the above species and somewhat resembles *C. flavomarginata* Scudd., but is smaller and has the lateral lobes of the pronotum more distinctly margined and yellow posteriorly.

Clinoppleura flavomarginata Scudder is dark brick-red and yellowish and closely resembles *C. melanoppleura* Scudd.

Clinoppleura minuta Caudell is also a dark species, but is smaller than any of the others. As in the case of the others it occurs in the southern and central parts of the State.

until summer, when mating and egg-laying begins, continuing until autumn.

Distribution.—This species is more often found in the San Joaquin Valley and southern parts of the State, having been collected in Fresno, Los Angeles, San Bernardino and Tulare counties.

Food Plants.—This insect, though not as destructive and numerous as the common grasshoppers, has done considerable to aid in the destructive work of the latter. It feeds on various kinds of vegetation, especially forage crops, including grasses, alfalfa, clover, etc.

THE ANGULAR-WINGED KATYDID

Microcentrum laurifolium Linnæus

(Figs. 29, 30)

Description.—The adult is a uniform green nearly throughout. The ovipositor of the female is short, strongly curved, with blunt, finely serrated tip. This species may be distinguished from the Mexican and California katydids by the spines on the front tibiæ. The eggs are light gray or brownish, flat, elongate-oval, about $\frac{1}{4}$ inch long, half as wide and glued usually in double rows on the twigs. The end of each egg overlaps the other, as shown in Fig. 29.

Life History.—The eggs are deposited in the fall and constitute the winter stage. In the spring the young katydids escape from the exposed ends and immediately begin work on the foliage, continuing their destructiveness throughout the spring, summer and fall. The broods are uneven, so all stages may be found throughout the summer.

Nature of Work.—The katydids are usually of little economic importance, though they are vegetable feeders. This is probably because of their inability to breed in great numbers, as do the grasshoppers. However, they do some damage by gnawing small, irregular holes in the rind of oranges when the fruit is small, producing eventually a large, ugly scar, as shown in Fig. 30.

Distribution.—This species is reported as occurring in the State by A. N. Caudell. It is evidently not very numerous, as few specimens are to be found in the collections of the State.

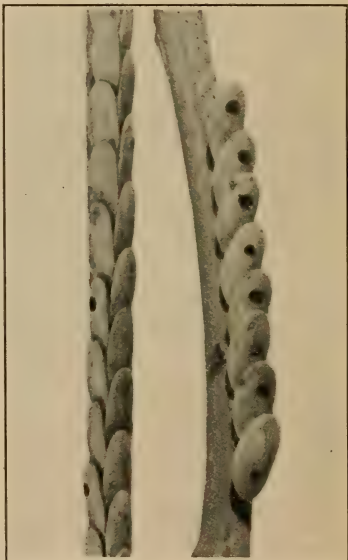


Fig. 29.—Eggs of the angular-winged katydid attached to twigs. The holes have been made by the egg parasite, *Eupelmus mirabilis* (Walsh). Enlarged twice. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

Food Plants.—The katydids feed upon various plants and have caused noticeable damage to the fruit of the orange.



Fig. 30.—Orange showing the work of katydids. Natural size. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

Control and Natural Enemy.—Due to the small amount of damage done, control measures are unnecessary, from an economic viewpoint. A small egg-parasite, *Eupelmus mirabilis* (Walsh) does great execution in destroying the eggs and serves to hold the insect in almost complete control.

THE CALIFORNIA KATYDID

Scudderia furcifera Scudder

(Fig. 31)

Description.—The adults are uniformly light green with the posterior half of the abdomen yellowish. The front tibiae are unarmed. The hind-wings are $\frac{1}{4}$ inch longer than the front and the hind femora are about half as long as the wings. The length including wings is from 2 to 2 $\frac{1}{4}$ inches.

The eggs are oval, flat, white or grayish brown and laid in rows overlapping like shingles. They may be laid in a single row around the edges of the leaves or on the branches or in double rows on the latter, much as those of the angular-winged katydid. The young katydids are bright green and have very long legs and antennae in proportion to the small bodies.



Fig. 31.—The California katydid, *Scudderia furcifera* Scudd. Male, natural size. (Original)

The young katydids are bright green and have very long legs and antennae in proportion to the small bodies.

Life History.—The life history of this species does not appear to differ greatly from that of the angular-winged katydid. The eggs of this genus are usually inserted into the edges of the leaves, but Professor Woodworth has reared the adults from the eggs laid as described above.

Nature of Work.—The katydids eat small holes in the rind of the fruit when it is still green. As the fruit grows the injury enlarges. This injury is often quite general and entails a considerable loss in some districts.

Distribution.—This species is quite widely distributed throughout the State.

Food Plants.—The katydids are quite general feeders and seldom prove serious to any one crop. In some localities the foliage and fruit of orange trees are attacked. The rind of the fruit while still young is eaten and develops deep, ugly scars, rendering the fruit unfit for market.

THE MEXICAN KATYDID

Scudderia mexicana (Saussure)

(*Phaneroptera mexicana* Saussure)

(Fig. 32)

Description.—This species greatly resembles the preceding one in general appearance and size. The chief difference is in the length of the hind femora, which almost extend to the tip of the wings.

Life History.—The life history is not known. The eggs are probably inserted in the edges of the leaves.

Nature of Work.—The work is the same as that of the angular-winged katydid.

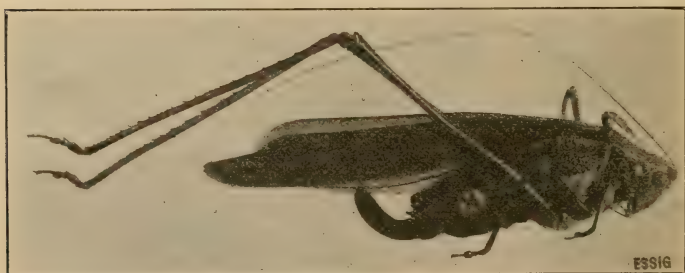


Fig. 32.—The Mexican katydid, *Scudderia mexicana* (Sauss.). Female, enlarged nearly twice. (Author's illustration, Mo. Bul. Cal. Hort. Com.)²²

Distribution.—This species occurs throughout the State, but is more common in the southern part.

Food Plants.—This species lives upon the foliage of various plants, but often attacks the leaves and fruits of the orange trees, much as does the preceding species.

²²This figure was erroneously labeled *Microcentrum laurifolium* Linn. in the first edition.

THE SAND OR JERUSALEM CRICKET

Stenopelmatus irregularis Scudder

(Fig. 33)

Description.—This is a wingless insect of a light brown or amber color, with the abdomen dark excepting an extreme posterior band around each segment, which is amber and gives a decided striped appearance. (Fig. 33.) The antennæ are long and filiform; the legs, large and strong. There are two noticeable horn-like processes on each side of the posterior end, which stand perfectly upright. They are light in color and slightly hairy. The ends of all spines on the legs



Fig. 33.—The sand or Jerusalem cricket, *Stenopelmatus irregularis* Scudd. Enlarged one and one half times. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

are black. The length of the adults varies considerably, but the largest are $1\frac{3}{4}$ inches long. This species is separated from others by having five inner spines above on the hind tibiæ, the third and fourth of which have the greatest interspace between them.

Life History.—The life history of this species is not well known. Much of the time is spent underground, especially during the day, while at night it makes excursions above ground and is often quite plentiful in the fall and early spring.

Distribution.—This species is more particularly confined to the central and southern parts of the State, though it also occurs in the

northern part, especially in the Sacramento Valley and the San Francisco Bay region.

Food Plants.—The feeding habits of these peculiar insects are not well known. Some are carnivorous, while others are believed to feed upon decaying vegetable or animal matter. However, we do know that they are often responsible for considerable damage to potatoes before they are dug. The tubers are gnawed so as to be unfit for keeping or selling. Occasionally a large proportion of the crop may thus be injured, but this is more likely to occur only in small newly-cleared areas.

Control.—The most injury is done in fields placed under cultivation for the first time or lands left for some time to sod or pasture. Well cultivated fields seldom, if ever, suffer from the attacks of this pest. Clean cultivation around the fences, so as to break up the breeding places, will practically eliminate all possibilities of injury, but even this is hardly to be recommended as a practical method of control.

ACRIDIIDÆ (Family)

SHORT-HORNED GRASSHOPPERS OR TRUE LOCUSTS

The insects of this family include the most destructive members of the entire order and are common practically everywhere. They are separated from the other families by their short antennæ, which are seldom if ever as long as the body; by the three-jointed tarsi; and by the short four-valved ovipositor. The hind legs are large and strong to enable them to travel rapidly by jumping. With the exception of a comparatively few species all have well-developed wings and some of them are able to make long and continuous migratory flights.

They are rather prolific and may increase in such numbers as to cause great ruin to vegetation. Certain species habitually migrate long distances, leaving a trail of devastation in their wake. The eggs are usually laid at the bottom of a hole drilled into the soil by the tip of the abdomen of the female. As the winter of most species is passed in this stage, the eggs are thoroughly protected from cold and moisture by a frothy cement secreted by the female for this purpose. In the spring the young grasshoppers emerge from the holes and begin to feed upon the first green vegetation and to develop very rapidly. In the early fall they begin to mate, the females depositing their eggs before winter.

Control.—The control of grasshoppers is often a perplexing problem, due to their great numbers and migratory habits. Their appearance is often so sudden as to take the farmer wholly unawares and the damage is done before he can defend his crops. Extensive experiments on control work have been conducted by trained men all over the world, the results of which have made the grasshopper invasions less dreaded. The reclamation of arid lands and the extension of agriculture to the foothills and deserts have eliminated many of the old and favorite breeding places, and greatly reduced the

size and numbers of migrations. In this State the most destructive species are controlled as follows:

Poisoned Bran.—In California the poisoned bran bait has proven exceedingly effective. This is recommended by J. S. Hunter (Bul. 170 Cal. Agrel. Exp. Sta.), as follows:

Wheat bran	40 pounds.
Molasses (cheapest)	2 gallons.
White arsenic	5 pounds.

The bran should be wet so that the water can be squeezed out of a lump held in the hand. After this, stir in the molasses and then the white arsenic. Let it stand over night and stir well before placing in the field, so as to allow the poison to penetrate every particle. The poison should be scattered in small piles, about the size of a hen's egg, in front of the path of the grasshoppers throughout the infested area. In orchards the poisoned bait should be placed at the trunk of each tree. This bait should be either occasionally moistened or renewed.

Citric Bran Mash.—A modification of the common bran mash by the addition of oranges or lemons has been recommended by Hunter and Claassen²³ and used with remarkable success. The formula is in two parts as follows:

I. Bran	50 pounds.
White arsenic or Paris green	2½ pounds.
Mix these dry.	
II. Lemons, including rind, chopped fine	½ dozen.
Syrup or molasses (cheap)	4 quarts.
Water	5 gallons.
Mix thoroughly by vigorous agitation.	

For use, mix I and II and add sufficient water to make a wet mash. They should not be mixed until just before the distribution of the poison. Distribute the mixture early in the morning between 4 and 7 o'clock, as the grasshoppers eat it more readily then.

Oranges or vinegar may be substituted for lemons, but do not give nearly as good results.

This citric bran mash was used in Ventura County in the early summer of 1914 by Horticultural Commissioner R. S. Vaile to head off an invasion of the pellucid grasshopper (*Camnula pellucida* Seudd.). It proved to be a remarkable success and entirely accomplished the desired results.

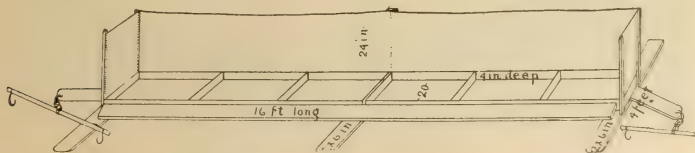


Fig. 34.—Plan of a hopper-dozer. (After Urbahns)

Criddle Mixture.—This is one of the poisons used in the East and Middle West with great effectiveness and is prepared as follows:

Paris green	1 pound.
Common salt	2 pounds.
Fresh horse dung	60 pounds.

²³Hunter, S. J. & Claassen, P. W., Jr. Ec. Ent. VII, p. 76, 1914.

The paris green is first mixed with water to form a paste and then thoroughly stirred into the horse dung with the salt. The mixture is then scattered in some such manner as is the poisoned bran. It also has the advantage of being less of a menace to birds, practically all of which are grasshopper destroyers.

Protecting Orchard Trees.—The general practice has long been to whitewash the trunks of trees to prevent the grasshoppers from crawling up into them. If occasionally renewed the whitewash does great good in this way and is worthy of recommendation.

A broad tanglefoot band near the base of the tree trunks will catch many of the grasshoppers, but if not applied very thickly, the larger and stronger ones will pull out.

Poison baits placed at the bases of the trees will keep most of the insects from attempting to ascend to the foliage.

Cultivation.—As previously stated, the grasshoppers lay their eggs in the fall in small holes an inch or two deep in the soil. The eggs do not hatch until spring. Late fall or winter plowing from four to six inches deep destroys the eggs and is a very successful control measure.

Some of the greatest menaces are the lands held for sale or from the market by speculators, who are indifferent to the ravages of these pests. Such localities afford excellent breeding places and in every community where the grasshoppers are bad steps should be taken to see that such places are plowed during the winter months.

A thorough harrowing or disking after a rain does much good also.

Burning.—Another means of reducing the pests is to burn the grass or stubble of the breeding places or infested field when the grasshoppers are most plentiful; or when the females are collecting on the breeding grounds to begin egg-laying. The best time for firing is during the night, when the insects are less active and are unable to escape the



Fig. 35.—Hopper-dozer at work. (Photo by E. F. Siegfried. Original)

approaching flames by flight. Of course, only waste stubble or pasture lands can be so treated, but these are usually the favored breeding places. Great care should always be exercised to see that sufficient help is ready to keep such a fire under complete control.

Hopper-dozer.—The use of the hopper-dozer is an important factor in the control of grasshoppers, especially in grain and hay fields, in

pastures and even in cultivated areas. The hopper-dozer is constructed as shown in Figs. 34, 35. The back and sides are made of thin sheet iron or cloth and the pan at the bottom is constructed to hold about two inches of water and kerosene or crude oil. These hopper-dozers may be made any length but one easily drawn by two horses is the most practicable. They are simply drawn across the fields as a sled and capture the grasshoppers as they endeavor to escape the apparatus. Though the insects may escape from the kerosene or oil bath they are nevertheless doomed.

The best time of operation is on warm days early in the season before the grasshoppers have acquired wings.

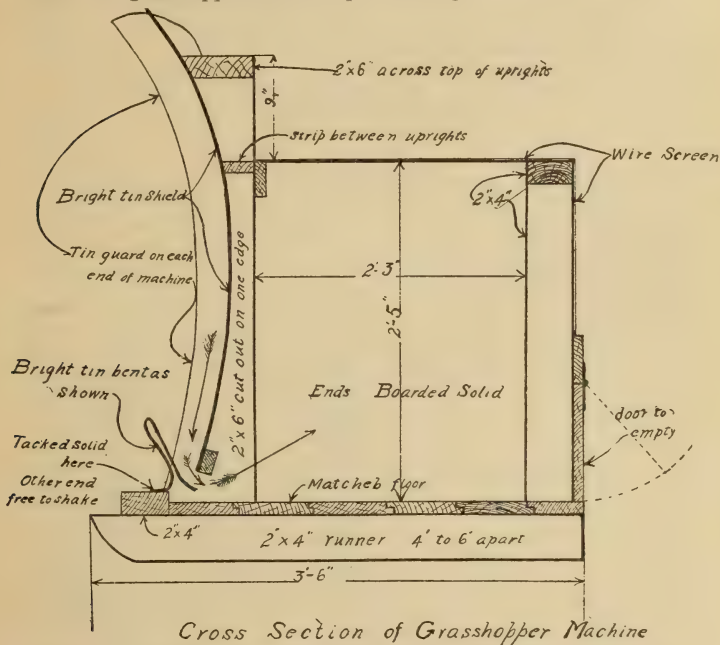


Fig. 36.—A grasshopper machine constructed without an oil pan for use in hilly or rolling districts. (Wyo. Agrcl. Exp. Sta.)

Natural Enemies.—There are many natural enemies of grasshoppers, which play a very important part in their control. In this work only the most common ones will be mentioned.

Parasitic Enemies.—The eggs of these parasites are usually laid on the surface of the living grasshoppers. Upon hatching the larvæ make their way into the body and feed upon the internal organs, eventually killing the host. The tachina flies, bombylid flies, flesh flies (*Sarcophaga* sp.) and some other dipterous insects are notably destruc-

tive to grasshoppers. Hair worms (*Gordius* and *Mermis*) feed within the bodies and a fungus (*Empusa grylli*) kills many grasshoppers in damp weather.

Predaceous Enemies.—The predaceous ground beetles (*Carabidæ*), tiger beetles (*Cicindelidæ*), robber flies (*Asilidæ*), wasps (*Sphecina* and *Vespina*) all prey on the young and adult grasshoppers.

Egg Destroyers.—The most noted destroyer of eggs is the locust mite (*Trombidium locustarum* Riley). Other mites and the following insects also prey upon them: the anthomyia egg-parasites (*Anthomyia* sp.) and a chalcid (*Caloptenobia* sp.) are parasitic; the larvæ and adults of the predaceous ground beetles, and soldier-beetles (*Chauliognathini*) and the larvæ of the robber flies and blister beetles (*Meloidæ*) all feed on the eggs.

THE YELLOW-WINGED OR PELLUCID GRASSHOPPER

Camnula pellucida Scudder

(Fig. 37)

Description.—The adults are slightly over 1 inch in length and quite variable in color, ranging from light yellow to dark ashy-brown, with well-defined black markings and two amber lines along the angles of the tegmina, noticeable when resting. These lines merge about one third the distance from the base. The head and thorax are darker than the abdomen. The basal halves of the antennæ are light while the apical portions are dark. The first two pairs of legs and hind femora are concolorous with the body, the hind femora also having darker markings, while the hind tibiæ are light yellow. The young are very dark in color, often almost black.

Life History.—This is one of the well-known migratory species, often flying in great swarms, and is sometimes a pest in the more northern states west of the Mississippi River, and in those just east of it too. The eggs are laid in small sacs in sandy or gravelly soil. They are deposited during August and hatch in May and June. The growth of the young grasshoppers is very rapid, so that within a month they have acquired wings and are ready to migrate. The breeding places are often located in the higher altitudes, and the adults migrate to the lowlands, many remaining along the path to lay their eggs for the following year. In the fall the species returns to old or selects new breeding grounds to deposit the overwintering eggs.



Fig. 37.—The pellucid grasshopper, *Camnula pellucida* Scudder. Natural size. (Original)

Distribution.—This species is common throughout the State and often becomes a serious pest in the central and southern parts, especially in or near low hilly districts.

Food Plants.—The pellucid grasshopper is specially destructive to grasses, including barley, oats and wheat. Alfalfa is seldom attacked. Sugar beets and other field crops are sometimes seriously injured, a special case of this kind occurring in Ventura County in the early summer of 1914.

THE LESSER MIGRATORY LOCUST²⁴

Melanoplus atlantis Riley

Description.—The adults are dull brownish with a row of distinct dark spots along the middle of the wing covers, which are considerably longer than the body. The dark bar on each side of the prothorax is broken near its middle. The tip of the last abdominal segment is pointed above with a notched apex. The average length is about 1 inch.

Life History.—The eggs are deposited in a pod resembling a flask just beneath the surface of the ground, each female laying from one to four masses containing from twenty to thirty-six eggs in each. The young hatch the following spring and maturity is reached in from two to three months. Eggs are deposited in July and August and during warm late seasons some of these hatch giving rise to an imperfect second brood. It is migratory in habit and under favorable climatic conditions increases very rapidly, often becoming a serious pest. It has no particular breeding ground.

Distribution.—This is a species which is widely dispersed and may be found in all parts of the State.

Food Plants.—Like many others, this grasshopper attacks nearly all kinds of cultivated and non-cultivated crops. Grasses, forage crops as alfalfa, clover, timothy, garden crops like corn, muskmelon, potatoes and watermelon are devoured.

THE TWO-STRIPED GRASSHOPPER

Melanoplus bivittatus (Say)

(*Gryllus bivittatus* Say)

Description.—This species varies considerably in size and color but is usually olive green or dark brown and slightly over 1 inch long and $\frac{1}{4}$ inch wide at the base of the wings. There is a distinct yellow stripe on each side of the dorsum from which the common name is derived. The tibiae vary from yellow to red. It is decidedly more robust than the other common species of the genus which are native to the State.

Life History.—This form occasionally makes flights with other species, but its attacks are usually local. It often becomes abundant enough, however, to do much damage. It appears about March and

²⁴The Rocky Mountain locust, *Melanoplus spretus* Uhler, is taken sometimes in this State on the eastern slope of the Sierra Nevada Mountains, but as it has never become of economic importance a description is not included here.

the sexes mate in July and August. Egg-laying begins the last of August and continues through September and the early part of October.

Distribution.—The two-striped grasshopper occurs throughout the State, but is more abundant in the interior valleys and the Sierra foothills.

Food Plants.—Like many other species of this genus, the two-striped grasshopper prefers green succulent vegetation as alfalfa, clover, corn, rank weeds, oats, grass and other plants of similar character.

THE DEVASTATING GRASSHOPPER

Melanoplus devastator Scudder²⁵

(Figs. 38, 39)

Description.—This is one of the smaller grasshoppers, averaging about 1 inch in length. The general color is amber or brownish with dark markings on the sides of the prothorax and on the tegmina. On the hind femora there are three distinct dark spots and dark tip. The hind tibiae are distinctly blue at their bases, gradually becoming amber towards the tips. The hind or true wings are transparent. The antennae are light amber. The young are lighter in color and usually without markings.

Life History.—This is partially a migratory species which at times works from the foothills to the cultivated lands below. The eggs are deposited in the ground in the foothills, which are the special breeding grounds. Late in June the grasshoppers often become very destructive and though they feed mostly on the grass of the ranges, fruit trees and small crops in those regions are often completely destroyed. In the late summer and fall the adults collect in the breeding places and deposit their eggs for the next year's broods.

Distribution.—This is the most abundant of the destructive grasshoppers and is found



Fig. 38.—The devastating grasshopper, *Melanoplus devastator* Scudd. Slightly enlarged. (Original)

²⁵A variety (*Melanoplus devastator conspicuus* Scudd.) is somewhat larger than the above with more pronounced black spots on the front wings.

throughout the State. Serious attacks in the State date back as far as 1722.²⁶ It appears to be specially destructive in the San Joaquin and Sacramento valleys.

Food Plants.—The food plants of this pest are about the same as for most grasshoppers and include grasses, foliage of deciduous trees, cultivated and wild, as apple, apricot, almond, peach, pear, plum, prune and quince, nearly all cultivated crops and succulent vegetation, as alfalfa, clover, corn, grape, etc. Grain and hay crops of barley, oat and wheat often suffer from the attacks, but they are usually harvested before the grasshopper is at its worst.



Fig. 39.—The conspicuous devastating grasshopper, *Melanoplus devastator conspicuus* Scudd. Enlarged nearly twice. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

THE DIFFERENTIAL GRASSHOPPER

Melanoplus differentialis Thomas

(Fig. 40)

Description.—This is one of the larger grasshoppers, averaging $1\frac{5}{8}$ inches from front to the tip of the tegmina or wing covers. It

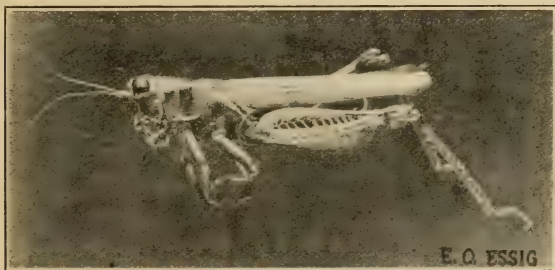


Fig. 40.—The differential grasshopper, *Melanoplus differentialis* Thomas. Natural size. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

is a very beautifully colored insect when fully matured. The head, thorax, abdomen and first two pairs of legs are amber or rich brown, the sutures being dark. The wing covers are brownish gray and the hind wings transparent. The hind femora are yellow marked with black cross lines, while the tibiae and tarsi vary from yellow to

²⁶Sanderson, E. D., Ins. Pests, Farm, Garden and Orchard, p. 99, 1912.

bright red. The former have black spots near the outer base. The spines and claws are black. The antennæ are reddish with dusky tips. The nymphs are green.

Life History.—Egg-laying begins about the middle of the summer. The holes for the eggs are drilled in the soil in bare and vacant places, especially in alfalfa fields. From sixty to eighty eggs are laid by each female. They are protected from winter rains and freezes by an excretion of the female which makes the capsule containing them waterproof. They begin to hatch in the warmer spring months, appearing early in June and keep up their destructive work until August. The young green nymphs, as they mature, acquire wings and assume a yellowish tint, thus giving rise to the belief that they are a distinct species. The largest brood appears early in the summer, and the greatest amount of damage is done by the first of August.

Distribution.—This species has a wide range throughout the State. It has often been quite a serious pest, especially in the San Joaquin Valley.

Food Plants.—The differential grasshopper prefers rank, green vegetation and is especially destructive to alfalfa. Practically all kinds of vegetable and truck crops are devoured, as beets, corn, potatoes, etc. Orchard trees and grapevines are also attacked, the trees and vines being often completely defoliated and many killed.

THE RED-LEGGED GRASSHOPPER.

Melanoplus femur-rubrum (De Geer)

(*Acridium femur-rubrum* De Geer)

Description.—The adults vary from olive-green to dull brown and have a row of dark specks along the middle of the wing covers, a continuous black bar on each side of the prothorax and a yellow line on each side of the body beneath the wings. The wing-covers are but slightly longer than the body and the hind tibiæ and tarsi are almost always red with black spines. The tip of the last abdominal segment of the male has a smooth rounded edge. The length is about 1 inch and the width at the base of the wings $\frac{1}{3}$ inch. The young are light amber brown or yellowish.

Life History.—The eggs are laid in late September or October and hatch the following spring. The adults mature in about two and one-half months and have wings by the first of August. There is but one brood a year. It is not a true migratory form, but sometimes gathers in swarms, which move with the winds much as do migratory species.

Distribution.—This grasshopper occurs throughout the State.

Food Plants.—This insect prefers rank or succulent vegetation in low places. It attacks alfalfa, clover, corn, grass, oat, barley, wheat and other cultivated garden crops.

THE PALE-WINGED GRASSHOPPER

Melanoplus uniformis Scudder

Description.—This species is characterized by the light uniformly colored bodies, which vary from dark straw to amber. The wing

covers are grayish. The tips of the hind femora have two long, lateral, dark spots and there are usually indications of the three dark blotches. The tibiae of the hind legs are very pale-blue. The length of the adult is slightly over $1\frac{1}{4}$ inches. The young are somewhat lighter in color.

Life History.—This is a truly migratory species, being very restless and hardly remaining long enough in one place to become harmful. Within the State the first migrations occur in the San Joaquin Valley in the Turlock and Newman districts during the early part of June.²⁷ The swarms continue to move about through September. The young reach maturity slowly and mating begins in August. The eggs are deposited in October and November and hatch as soon as the ground becomes warm the following spring.

Distribution.—It is especially abundant in the central San Joaquin Valley, in the region southeast of Turlock, but the range comprises much of the central part of the State.

Food Plants.—The hosts are practically the same as for the differential grasshopper, though it is not so destructive to the crops.

THE VALLEY GRASSHOPPER

Edaleonotus enigma Scudder

(Fig. 41)

Description.—This is also one of the smaller species, the adults being about 1 inch long and somewhat robust. The general color is rich amber with reddish hue around the eyes. The dorsum and carinae of the thorax are dark. The tegmina are mottled with black and dusky spots. The antennae and first two pairs of legs are concolorous with the body, while the femora of the hind legs are richly marked with black

and the tibiae are pale blue. The young are nearly of the same general color, with the dark markings less pronounced.

Life History.—The holes in which the eggs are laid are usually drilled in hard or compact soil. The eggs are laid regu-

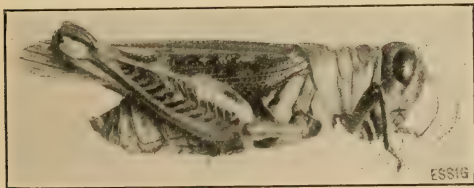


Fig. 41.—The valley grasshopper, *Edaleonotus enigma* Scudd. Enlarged twice. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

larly and horizontally and cemented together, as well as being surrounded with a liquid cement which renders the mass waterproof. The young hatch the following spring, as soon as it becomes warm, and they begin to reach maturity early in June. Pairing begins soon after and eggs are deposited from August to October. There are two forms of the adults, characterized by long and short wings. This species is very prolific and does much damage. It is distinctly and regularly migratory, but always on foot.

²⁷Hunter, J. S., Bul. No. 170, Cal. Agrcl. Exp. Sta., p. 5, 1905.

Distribution.—This species is widely distributed throughout the State, but is most abundant in the San Joaquin and Sacramento valleys.

Food Plants.—All forms of vegetation, including the foliage of orchards and vineyards, uncultivated field crops, such as alfalfa, clover, barley, oat, wheat, etc., and cultivated crops, such as vegetables, corn, potatoes, etc., are attacked.

THE LARGE VAGRANT GRASSHOPPER

Schistocerca vaga (Scudder)²⁸

(Fig. 42)

Description.—This is a very large species attaining a length of from 2 to 2½ inches. The general color is light brown with a light longitudinal stripe on the dorsum and distinct dark spots on the wing covers. The posterior tip of the pronotum forms a right angle.

Life History.—The vagrant grasshopper is non-migratory and is seldom found excepting singly. The winter is passed in the adult and

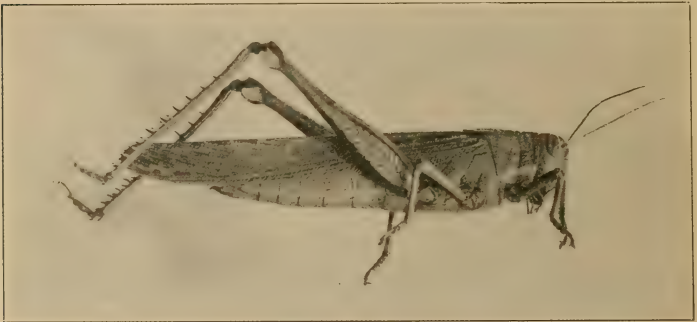


Fig. 42.—The large vagrant grasshopper, *Schistocerca vaga* (Scudd.). Slightly enlarged. (Original)

not in the egg-stage as is the case of the more destructive species already referred to. The eggs are laid in fields and pastures in the spring about May and the young come to maturity by fall. There is but one brood a year.

²⁸Key to species of *Schistocerca* found in California. (By A. N. Caudell, Bur. Ent. U. S. Dept. Agric.)

- | | |
|--|--------------------------|
| a. Lateral lobes of the pronotum distinctly marked along the middle with a solid black longitudinal stripe---- | <i>vaga</i> Scudder |
| Lateral lobes of the prothorax immaculate, without solid longitudinal black stripe----- | b |
| b. Pronotum with a median dorsal stripe which continues more or less along the closed tegmina----- | c |
| Pronotum without median dorsal stripe----- | d |
| c. Posterior tibiae red ----- | <i>venusta</i> Scudder |
| Posterior tibiae not red ----- | <i>alutacea</i> (Harris) |
| d. General color greenish, the elytra almost or quite immaculate and the posterior tibiae red----- | <i>shoshone</i> Thomas |
| General color brown, the elytra more or less distinctly maculate and the posterior tibiae not red----- | <i>carinata</i> Scudder |

Distribution.—This species appears to be limited to the southern part of the State, but other species referred to in the footnote may be found generally distributed in all parts of the State.

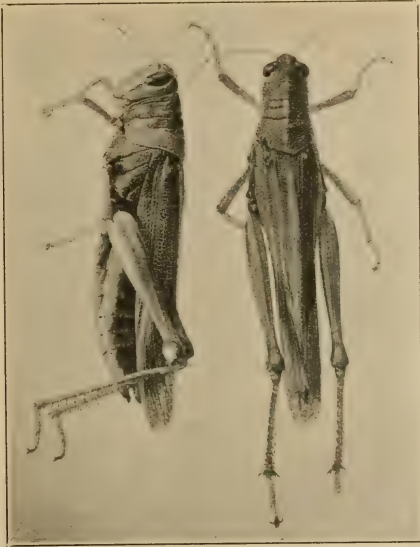


Fig. 43.—*Schistocerca venusta* Scudd. Slightly enlarged. (Original)

Food Plants.—All of the members of the genus *Schistocerca* do more or less damage, especially to orange, lemon and other fruit trees, but they are seldom abundant enough to warrant control measures.

THYSANOPTERA (Order)

FRINGED-WINGED INSECTS

THRIPS

The numerous species of the minute fringed-winged insects, known as thrips, are placed in a single order as given above. These insects, though exceedingly small, may be readily observed by simply shaking almost any flower, especially the sunflowers and their allies, into the hand and observing the small yellowish or brownish slender individuals crawling out in the palm of the hand. They hop and fly very readily. The eggs are laid upon the outside, or within the tissues of the plant. In the latter case the female inserts the egg with her sharp ovipositor. The insects have direct, simple or incomplete transformations, the larvæ greatly resembling the adults. The larvæ of some species go into the ground for hibernation and pupation, the adult insects emerging in the early spring. The mouth-parts are modified so that the insects pierce or chafe rather than bite, and due to their constant work and tremendous numbers are able to accomplish very disastrous results. Some species work principally upon the young buds and flowers, though they often do considerable damage to fruits and foliage.

In this State thrips have been considered most serious pests, especially in the Sacramento and San Joaquin valleys, where thousands of dollars have been spent in their control.

During the last two years, however, the amount of spraying has been greatly reduced because many growers believed that the cost did not warrant the benefits derived.

The control measures vary somewhat and are given under each individual species.

Several species have been known to be attacked by internal hymenopterous parasites, but the exact amount of this parasitism for the various species is not well known.

THE WHEAT THRIPS²⁹

Frankliniella tritici (Fitch) (Family Thripidæ)

[*Euthrips tritici* (Fitch)]

(*Thrips tritici* Fitch)

(Fig. 44)

Description.—The adults of this species are noticeably longer than any of the other common species. The color is amber or brownish and the head and thorax are distinctly yellow or orange-colored, which make it easily recognized at once with the naked eye. The eggs are very minute, globular and red. The young greatly resemble the adults, but are much smaller and a little paler.

Life History.—The life history of this species is practically the same as for the bean thrips.

Nature of Work.—Besides causing the small discolored spots on the foliage, this species is very destructive to the pistils of the flowers

²⁹This species is also known as the flower grain and strawberry thrips and is the common alfalfa thrips of California.

of many plants, but especially the strawberry. It also feeds upon the fruit of the orange, causing a russetting, as does the citrus red spider.



Fig. 44.—Alfalfa leaves showing wheat thrips *Frankliniella tritici* (Fitch), and the discolorations caused by their work. Enlarged three times. (Original)

Distribution.—This is one of the most abundant species throughout the entire State. It is specially common in alfalfa fields.

Food Plants.—Alfalfa, grass, lilac, manzanita, orange, rose, California sage, and strawberry are recorded as hosts of this thrips.

Control.—Control measures for this thrips are the same as recommended for the bean and citrus thrips, depending upon the host attacked.

THE BEAN THRIPS

Heliothrips fasciatus Pergande (Family Thripidae)

(Figs. 45, 46)

Description.—The adult insect is black with head and thorax dark brown; antennæ are whitish with tips dark; legs are black and yellow; front wings are blackish with white base; posterior wings uniformly yellow with dark fringes. The young stages are lighter in appearance than the adult.

Life History.—According to Mr. H. M. Russell the insects hibernate in the adult stage only, under leaves, rubbish, etc. They begin to emerge about January and immediately commence egg-laying. The eggs are inserted in the leaves or tender stems. The young begin feeding soon after hatching. When ready to pupate the larvæ seek shelter under rubbish or in the ground, where the nymphal stage is completed and the adults emerge. There is an overlapping of broods, so that

during the summer months all stages may be found. A complete life cycle from egg to adult occupies about two months. The adults begin to hibernate during the months of October, November and December.

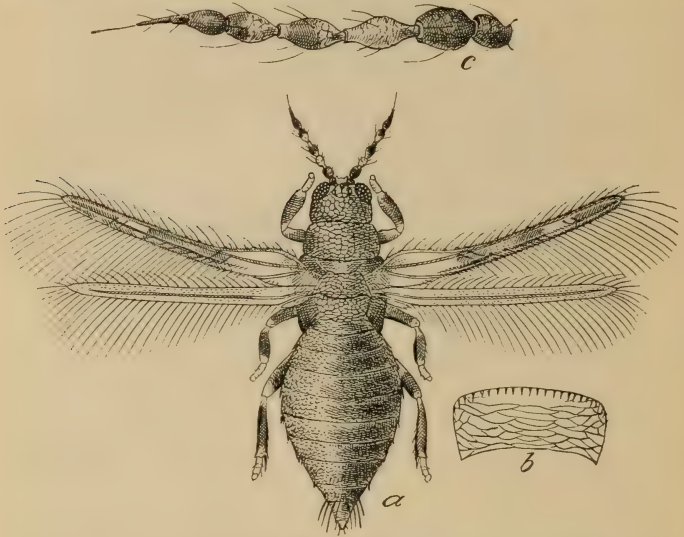


Fig. 45.—The bean thrips, *Heliothrips fasciatus* Perg. Greatly enlarged. (After Russell, U. S. Dept. Agric.)

Nature of Work.—The thrips chafe the epidermis of the foliage and fruit, causing a discoloration which assumes a whitish yellow-mottled effect on the foliage and a russety or scabby appearance upon the fruit. Infested plants are stunted or their foliage dropped prematurely by severe infestations.

Distribution.—The bean thrips are distributed throughout the entire State. It was first collected by Geo. W. Harney, present horticultural commissioner of Yuba County, in 1894.

Food Plants.—Due to its large numbers this thrips is often quite damaging and may prove a serious pest to any of the following plants: Alfalfa, bean, beet, *Bidens pilosa*, clover, *Chenopodium murale*, cotton, hawkseed (*Crepis*), *Eunanus brevipes*, *Euryptera lucida*, cudweed (*Gnaphalium californicum*), wild heliotrope, lettuce, California four-o'clock (*Mirabilis californica*), nasturtium, tree tobacco (*Nicotiana glauca*), orange, pea, peach, pear, wire grass (*Polygonum aviculare*), radish, sow-thistle, *Tacsonia mollissima*, tulip, turnip, and mullein (*Verbascum virgatum*).

Control.—Like mites, thrips are very difficult to control because of their large numbers, exceedingly small size and the tender plants which they infest. Many sprays will readily kill them, because of their small size, but the nature of the host plant does not always permit of

such treatment. Tobacco decoctions and lime-sulphur or oil emulsions give very good results. The following formula is recommended by J. R. Watson³⁰:

Commercial lime-sulphur (33° Baumé)-----	5½ gallons
"Black Leaf 40" (tobacco decoction)-----	14 fluid ounces
Water-----	200 gallons

The addition of one part of "black leaf 40" to two thousand parts of an oil emulsion or a miscible oil spray will also give good results.

On orange trees use the sprays recommended for the citrus thrips.



Fig. 46.—Bean leaves showing the work of the bean thrips, *Heliothrips fasciatus* Perg. Natural size. (Original)

To any spray a spreader composed of 4 gallons of flour paste (1 pound of flour to each gallon of water, dissolved to make a paste) to every 100 gallons will greatly aid and give much better results than if used alone.

Natural Enemy.—A single internal hymenopterous parasite (*Thripoctonus russelli* Crawford) has been reared from this species in California by H. M. Russell and J. E. Graf.³¹

THE GREENHOUSE THRIPS

Heliothrips hamorrhoidalis Bouché (Family Thripidae)

(Fig. 47)

Description.—The adult insect is characterized by having the antennæ eight-segmented and twice as long as the head, while the surface of the body is distinctly reticulated. The abdomen is yellowish brown, with head and thorax dark brown and antennæ, legs and wings colorless. The eggs are very minute, colorless and bean-shaped. The first hatched young are colorless with seven-jointed antennæ. As they grow older the color becomes darker until the

³⁰Rept. Fla. Agrcl. Exp. Sta., pp. 61-62, 1912.

³¹Tech. Ser. No. 23, Pt. II, Bur. Ent. U. S. Dept. Agric., 1912.

head and thorax are dark brown and the abdomen yellowish brown with lighter anal end. The antennæ also become eight-jointed.

Life History.—The small eggs are inserted into the epidermis of the leaves usually on the undersides, in the spring, each female laying from ten to twenty. They hatch in about ten days. The larval and pupal stages cover a period of from four to six weeks. All stages are very active and feed upon the flowers and foliage. There are many generations a year.

Nature of Work.—The work of this species is practically the same as that of the bean thrips.

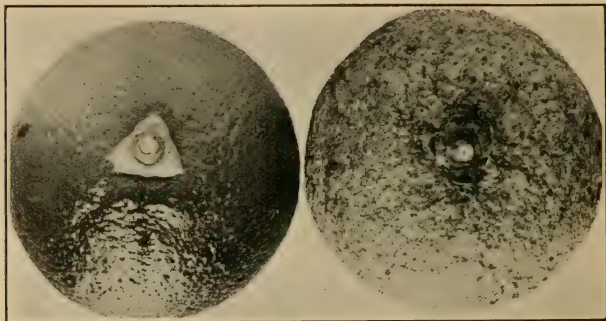


Fig. 47.—Orange at right showing the work of the greenhouse thrips, *Heliothrips humorrhoidalis* Bouché. (After Quayle, Cal. Agrcl. Exp. Sta.)

Distribution.—It occurs in greenhouses throughout the State and is also abundant in the open, especially in the central and southern parts of the State.

Food Plants.—Avocado, azalea, begonia, calla, *Cattleya*, cherry, citron, cocoa, croton, dahlia, ferns, fig, fuchsia, grape, grapefruit, kola, laurel, laurestinus, lemon, lilies, mango, maple, orange, Norfolk Island pine, palms, *Pellaea hastata*, phlox, pink, smilax, verbena, *Viburnum* and undoubtedly many other plants are attacked by this species.

Control.—Control measures are the same as for the bean and citrus thrips, depending upon the nature of the host.

THE CITRUS THRIPS

Scirtothrips citri (Moulton) (Family Thripidæ)
(*Euthrips citri* Moulton)

(Fig. 48)

Description.—The adult thrips are orange-yellow in color, with the thorax and the second antennal segment orange-brown. They are very minute, so small as to be scarcely observed by the average orchardist, being less than 1-30 inch in length and 1-100 inch in width.

Life History.—The winter is spent in the adult form or as eggs in the plant tissues. The thrips become especially abundant about the time the citrus trees are in bloom and begin their work as soon as

the petals fall and continue throughout the summer. The eggs are laid from May to August, hatching in six or ten days. The larvæ greatly resemble the adults, but are at first somewhat lighter in color. In from six to eight days they change into the pupal stage, and in another three to five days become adult insects. The entire life cycle, from the laying of the egg to the beginning of the egg-laying of the adults of the second generation is about twenty days. There are from eight to ten generations a year in the San Joaquin Valley, as estimated by Jones and Horton.

Nature of Work.—The presence of this insect is usually ascertained by the work, which consists in scarring the fruit in such a way as to form nearly regular circles around the stem and blossom ends, although

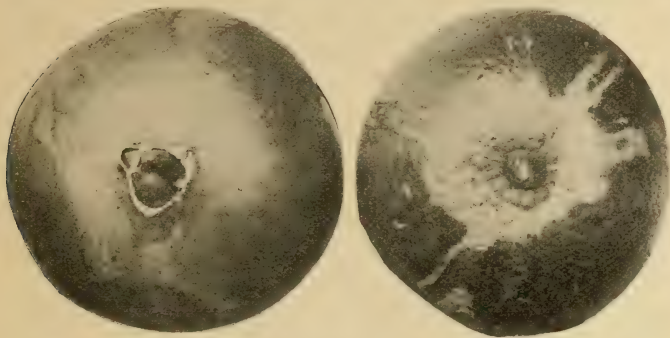


Fig. 48.—Oranges showing the work of the citrus thrips, *Scirtothrips citri* (Moulton). (U. S. Dept. Agric.)

these scars may extend almost over the entire surface. They also cause a characteristic crinkling and thickening of the young citrus foliage, by attacking the leaves just as the buds are unfolding.

Distribution.—Up to the present time the distribution of the citrus thrips is limited to the citrus sections in the San Joaquin Valley, along the western border of the Sierra foothills. This includes the Porterville and Bakersfield citrus belts.

Food Plants.—Apricot, citron, dock, grape, grapefruit, lemon, olive, orange, pear, pepper tree, pomegranate, purslane, raspberry, rose, *Solanum*, umbrella tree and willow are known food plants.

Control.—So far the best results in controlling the citrus thrips have come from spraying; experiments being conducted in California and Arizona with very good results. Two sprays were used in the work, lime-sulphur diluted at the rate of one part to eighty parts of water and tobacco extract (40 per cent nicotine), diluted one part to eighteen hundred parts of water. The lime-sulphur causes slight burnings, but otherwise is as effective and much less expensive than the tobacco extract. Four applications are recommended: the first just after most of the petals have fallen; the second in ten or fifteen days after the first; the third from three to four weeks after the second, and the fourth during the months of August or September, when the thrips

are numerous on the foliage. In spraying for this insect it is advisable to use angle nozzles and from 175 to 200 pounds pressure, care being taken that every portion of the tree is thoroughly drenched. The spraying for this species in California, however, has not proven profitable enough to justify its continuance, except in nurseries.

THE ONION THRIPS

Thrips tabaci Lindeman (Family Thripidæ)

Description.—The adult female is pale yellow in color with an elongated dusky spot on the dorsal surface of the middle thoracic segment. The length of the body varies from $\frac{1}{32}$ to $\frac{1}{16}$ inch. The eyes are brown, while the antennæ and legs are dusky. The wings are faintly yellowish, their fringes being dusky. The antennæ are seven jointed. The male larvæ are somewhat smaller than the female and of a darker color and often with a greenish tint. The eyes are red.

Life History.—The life history is practically the same as that of the bean thrips.

Nature of Work.—The constant chafing of the thrips upon the leaves produces countless numbers of small white or silvery spots which are very noticeable. The growth of the plant is often stunted by the attacks.

Distribution.—This species is generally distributed throughout the entire State. It is often very troublesome to onion growers in the warm interior valleys and in the Imperial Valley.

Food Plants.—The onion thrips is especially destructive to onions grown for seed. It damages the seed buds before the seeds have hardened and in many instances causes a complete failure of the seed crop. It is also destructive to cabbage, fruit trees, grass, muskmelon, pigweed, sunflower and many truck crops.

Control.—The remedies are the same as for the bean thrips.

Natural Enemy.—The internal hymenopterous parasite, *Triphoctenus russelli* Crawford, has also been reared from this species.³²

THE PEAR THRIPS

Taniithrips pyri (Daniel) (Family Thripidæ)

(*Euthrips pyri* Daniel)

(Fig. 49)

Description.—The eggs are very minute, white and bean-shaped. They are embedded in the tender tissues of the host. The first born larvæ are white, with distinct red eyes, and move slowly. They are often very thick on the trees and are known as "white thrips." Pupation takes place in the ground, the pupæ being white and seldom met with except by careful investigation. The adult insect is dark in color, varying from an amber to a dark brown or almost black and about 1-20 inch long. The presence of this species is usually told by ravages on the tender tissues of the expanding flowers and leaf buds and later by the attacks on the young fruit. In badly infested orchards the buds often fail to open and the whole orchard may present a brown fire-swept

³²Russell, H. M., Tech. Ser. M. 23, Pl. II, Bur. Ent. U. S. Dept. Agric., 1912.

appearance. The fruit may be scabbed and curled or otherwise deformed by the constant chafing.

Life History.—As stated above, the eggs are inserted in the stem, leaf or small fruits of the host. They hatch in from four to five days, the larvæ or "white thrips" beginning to feed at once and to do damage. When full grown, which takes from two to three weeks, these drop to the ground and after penetrating several inches enclose themselves in a small earthen cell, where they remain throughout the transforming or pupal period. This period usually begins about September and continues throughout the months of October, November and December, when adult insects are formed. These remain in the ground until February before emerging. The transformation from the larval to the adult stage occupies several months, the slow growth being probably due to the cold winter season.

Nature of Work.—The chief injury by this species is to the blossoms, so many of which may be destroyed as to greatly reduce or entirely eliminate the crop.

Distribution.—According to Paul R. Jones, formerly in charge of the pear thrips investigations in California for the United States Department of Agriculture, the pear thrips are now reported only in parts of the following counties: Alameda, Contra Costa, Napa, Sacramento, San Benito, San Joaquin, Santa Clara, Solano, Sonoma and Yolo.

Food Plants.—This insect is particularly a deciduous tree pest and works great damage to the leaf and flower buds, as well as to the young fruit. The initial damage is done just before or after

blossoming time. The pear suffers probably more than any other tree due to ravages of this insect, although prunes and plums are also severely attacked. Almonds, apricots and peaches also receive serious damage some seasons. The following are other hosts of this pest: apple, cherry, fig, grape and English walnut.

Control.³³—*Government Formula:* The formula which has given the best results is made up of the 3 per cent distillate oil emulsion, to which is added from 1 per cent to $1\frac{2}{3}$ per cent of tobacco extract No. 1 (black leaf containing 2.75 per cent nicotine) or tobacco extract No. 2 (sulphate of nicotine or black leaf 40), which is 40 per cent nicotine, at the rate of 1 part to from 1,500 to 2,000 parts of the spray mixture. The distillate oil emulsion may be obtained from several dealers in chemical and spraying supplies, or may be made at home. By the use of the home-made emulsion, a considerable proportion of the cost of spraying is often saved, and, what is more important, the quality of the emulsion is above reproach, when good materials are properly used in its manufacture and the emulsion properly made.

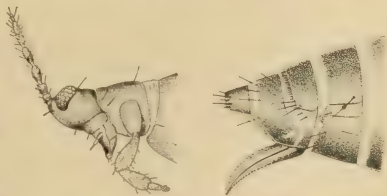


Fig. 49. — The pear thrips, *Taniethrips pyri* (Daniel). Head and tip of the abdomen. (After Moulton, U. S. Dept. Agric.)

³³By Paul R. Jones, San Jose, Cal.

Since the publication of the government circulars on this insect there has been a great improvement of commercial or proprietary miscible oils and emulsions, so that at the present time if the grower does not desire to make his own distillate oil emulsion he is able to select from three or four commercial products put out by reliable companies, and which are uniform in quality and which can be easily emulsified. These proprietary products are divided into two main groups: those of a mechanical type of emulsion similar to the stock home-made emulsions and running about 60 per cent oil, and those of the miscible oil type running from 85 to 88 per cent oil, besides containing a certain amount of phenols, which also have insecticidal value, and which many people claim act as a deterrent for the thrips. Those commercial preparations which run 60 per cent oil should be diluted to get a 3 per cent emulsion at the rate of 10 gallons per 200 gallon tank, while those of the miscible oil type, analyzing 85 to 89 per cent hydro-carbon oils and including 1 to 3 per cent phenols, should be used as advised by the companies making them. When used against adults the usual dilution of this type of oil sprays is 5 gallons per 200-gallon tank, combined with black leaf 40, 1-1,600, and from 3 to 4 gallons with the nicotine when used against larvæ.

Many of the miscible oils are made from a more penetrating oil than can be obtained by the average grower for making the home-made distillate oil emulsions, and in cases of severe thrips infestation will give better penetration, especially when used against adults when the buds are only slightly open.

The relative costs between home-made and proprietary insecticides, where the labor is not taken into consideration, is in favor of the home-made preparation. Home-made distillate oil emulsions run from 55c to 65c per 200-gallon tank, besides the quantity of nicotine. In the cheapest of the high-class commercial mixtures the cost runs from 75c to \$1.50 per 200-gallon tank besides the quantity of nicotine used. One disadvantage home-made distillate oil emulsion has is that if any is left over the next year it is practically worthless on account of breaking down, whereas the commercial product can be kept indefinitely.

Oftentimes a saprophytic fungus, commonly known as one of the blue molds, becomes very injurious in the pear buds following the attack of the adult thrips, which have caused the buds to drip or bleed. When this is present, a fungicide in the form of atomic or milled sulphur, at the rate of 20 to 24 pounds per 200-gallon tank, can be added to the Distillate Oil Emulsion-Tobacco, or Miscible Oil-Tobacco mixture. The sulphur will prevent and stop the spread of the blue mold, which often causes as much damage as the trips themselves.

In spraying for the larvæ or white thrips, a still greater combination can be used with advantage, as the time of application of this treatment usually falls at the time when the first codlin-moth application should be made on pears. For thrips larvæ, codlin-moth and pear scab use the above formula with the addition of 4 pounds of arsenate of lead per 100 gallons of mixture.

HEMIPTERA (Order)

HALF-WINGED INSECTS

CICADAS, LEAF-HOPPERS, TREE-HOPPERS, PLANT LICE, SCALE INSECTS,
WHITE FLIES AND TRUE BUGS

This is the sixth largest order in the number of species, and is one of the most destructive orders of insects. There are nearly twenty thousand known species. The front wings of the members of one of the suborders are thickened at the base, the tips being membranous and overlapping and appearing like half wings. This peculiarity probably gave rise to the name *Hemiptera*, which was applied to the whole order, though the majority of the members do not have such wings and many have no wings at all. The mouth-parts are constructed for piercing and sucking and never for chewing. The transformations or metamorphoses are incomplete, the young or nymphs differing from the adults chiefly in the lack of the development of sexual organs.

The order *Hemiptera* is usually divided into the three following suborders: *Homoptera*, *Heteroptera* and *Parasita* or *Anoplura*, only the first two of which will be considered.

HOMOPTERA (Suborder)

This suborder includes many insects which are quite destructive to plant life. Whenever wings are present they are held roof-like over the body and may or may not be membranous. The front of the head is bent under the body, so as to touch the bases of the front coxæ. In the families, *Psyllidæ*, *Aphididæ*, *Coccidæ* and *Aleyrodidæ*, however, the head is so fused with the thorax that one cannot demonstrate that it touches the coxæ.

The families of this suborder are:

- Fulgoridæ* (Lantern flies)
- Cicadidæ* (Cicadas or Harvest flies)
- Cercopidæ* (Spittle insects)
- Membracidæ* (Tree-hoppers)
- Jassidæ* (Leaf-hoppers)
- Psyllidæ* (Jumping plant lice)
- Aphididæ* (Plant lice)
- Coccidæ* (Scale insects)
- Aleyrodidæ* (Mealy wings or White flies)

As the *Fulgoridæ* and the *Cercopidæ* are of little or no economic importance in California they will not be considered in this work.

CICADIDÆ (Family)

CICADAS

The cicadas are well-known insects, being commonly called harvest flies or locusts. The proboscis rises plainly from the head; there are three ocelli present; the males have musical organs; the feet have three segments and the antennæ are very small and bristle-like. The eggs are laid by the female in small twigs, punctures being made by the ovi-

positor for their insertion. The only damage is caused by these egg-punctures. The young larvæ hatch within a few weeks and live throughout their entire existence under the ground, where they remain for two or more years, depending upon the species: the so-called seventeen-year locusts require exactly seventeen years in which to transform from the egg to the adult. The nymphal stage is passed in a small cell, also in the earth. When ready to change into the adult the nymph leaves the ground and crawls up some tree or shrub, where the back is split and the adult issues. In the Middle and Eastern States these insects appear in such great numbers during certain years as to become quite serious pests, their depredations sometimes being known as plagues. There are many species in California, though none of them are nearly as destructive as the seventeen-year locusts or the periodical cicada of the Eastern States. In fact, they are of very slight consequence here.

THE NET-WINGED CICADA

Platypedia areolata Uhler

(Fig. 50)

Description.—The adults are quite variable in color, but are usually dark-gray or nearly black with orange or yellow markings on the head and thorax. The mesothorax and metathorax are often entirely yellow, but more often only the sides are so colored. There is usually a longitudinal yellow line on the dorsum, a narrow yellow line across the front of the prothorax and a wide line of the same color between the mesothorax and metathorax. The legs are dark or light amber, the antennæ dark and the eyes black. The front margin of the front wings are bowed as much as the hind margin. The wings are widest near the tips and hyaline with yellowish base. The average length is about $\frac{1}{2}$ inch.

Life History.—The life history of this species is not known, other than that the eggs are laid in punctures made in the limbs by the females in the spring and early summer and that the larval and pupal stages are spent in the ground.



○ Fig. 50.—The net-winged Cicada, *Platypedia areolata* Uhler. Upper picture shows female twice enlarged. Lower picture shows females and egg punctures on peach twig. Natural size. (Original)

Nature of Work.—The damage consists in making the egg-punctures in the small twigs, which so weakens them that they break. Fig. 50 shows some of these egg-punctures.

Distribution.—This cicada occurs in the central and northern parts of the State, having been taken in the Santa Clara and Sacramento valleys.

Hosts.—Mr. Geo. P. Weldon collected numbers of the females laying eggs in olive branches at Chico, Butte County. It also punctures the limbs of peach and other fruit trees.

Control.—The extent of injury does not usually warrant any control measures. However, should this be the case the only recourse would be to prune out and burn the twigs containing the eggs before they hatch.

MEMBRACIDÆ (Family)

TREE-HOPPERS

The membracids are rather small insects, generally characterized by the prolongation of the prothorax, which covers nearly the entire abdomen. The antennæ are minute and bristle-like; the beak is plainly inserted in the head and the feet have three segments. The most common species of this family in California is the buffalo tree-hopper.

THE BUFFALO TREE-HOPPER

Cercsa bubalus Fabricius

Description.—The adults are small, oddly-shaped, light green hoppers, from $\frac{1}{4}$ to $\frac{3}{8}$ inch long and with a horn-like projection on each front margin of the prothorax. The eggs are transparently white, smooth, long, cylindrical, rounded at one end and tapering towards the other and about 1-17 inch long. They are inserted obliquely beneath the bark by the sharp ovipositor in groups of from six to twelve. The nymphs are light green and greatly resemble the adults, but are spiny, flattened and much smaller. When disturbed the insects hop quickly.

Life History.—The eggs are deposited into incisions cut in the upper surface of the bark of small branches from July to October and hatch in April, May or June. The young nymphs feed primarily upon grasses and weeds in or around the orchards and reach maturity in time to deposit eggs in the fall. There is but one brood a year.

Nature of Work.—The damage is done by the females in making the incisions in the twigs for egg-laying. They usually select young growth from two to three years old, and, as hundreds of incisions may be made by a single female, young trees are often entirely killed. As the egg scars heal roughened areas form upon the limbs, producing a knotty appearance.

Distribution.—This hopper occurs in limited numbers throughout the State, but so far has not proven serious in any locality.

Food Plants.—The insects feed upon many kinds of grasses and succulent vegetation, but the principal damage is done in making the egg-punctures in the limbs of various trees, including the following:

apple, cherry, *Prunus andersoni*, wild thorn (*Crataegus tomentosa*) and willow.

Control.—As the young feed upon vegetation allowed to grow in or around the orchards, it is important to practice clean culture, beginning not later than the last of April and continuing throughout the summer. The grass and weeds along the fences should also be destroyed. Pruning out the punctured branches during the winter will do much to reduce the spring brood.

Natural Enemies.—Two hymenopterous parasites, *Cosmocoma* sp. and *Trichogramma ceresarum* Ashm.³⁴ have been reared from the eggs of the buffalo tree-hopper. Neither of these, however, have been reported in this State.

JASSIDÆ (Family)

LEAF-HOPPERS

The leaf-hoppers are rather small insects and especially active, being able to jump so quickly that they are sometimes called "sharpshooters." They resemble somewhat the tree-hoppers but do not have the curious raised prothorax extending back over the abdomen. The hind tibiae are armed below with two rows of spines. The members of the family are exceedingly numerous and may be found upon many kinds of vegetation.

THE APPLE LEAF-HOPPER

♂ *Empoasca mali* LeBaron³⁵

(Fig. 51)

Description.—The adults are light yellowish-green with lighter spots on the dorsum of the head and a row on the front margin of the pronotum. The length is about $\frac{1}{8}$ inch. The nymphs are very pale and distinguished from the adults by the absence of fully-developed wings. The eggs are white, elongate, slightly curved and about 1-40 inch long.



♂ Fig. 51.—Adult of the apple leaf-hopper, *Empoasca mali* LeB. Greatly enlarged. (After Forbes)

Life History.—The winter is passed in both the egg and adult stages. The winter eggs are laid in the fall and are inserted just beneath the bark of two- or three-year-old wood. Small swellings on the surface mark the position of the eggs. Hatching begins in the early spring and the young at once begin to feed upon the leaves. On reaching maturity in about a month the summer broods begin to deposit eggs, which are inserted in the softer tissues of the petioles and larger veins of the

³⁴Insect Life VII, pp. 12-13, 1894.

³⁵The rose leaf-hopper, *Empoa rosa* (Linn.), is quite abundant on roses and often does considerable damage to the foliage of apple and pear trees in this state. (Fig. 52). Mr. Leroy Childs also reports this species injurious to fruit trees in Oregon. Specimens for the illustration were received from him.

leaves, especially of apple and alfalfa. There are from three to four broods a year. The adults hibernate in sheltered places, under leaves, in the grass and weeds.

Nature of Work.—During the summer and fall months the leaf-hoppers often become exceedingly abundant, and do much damage by attacking the new growth at the tips of the branches, causing the leaves to turn yellow and curl, and thereby stunting and producing undersized trees. Young nursery trees suffer most. On older trees they work usually upon the undersides of the leaves.

Distribution.—This leaf-hopper is apparently limited in its distribution in the State.

Food Plants.—Though the apple leaf-hopper is primarily a nursery pest, affecting especially apple trees, a large number of plants are attacked, including alfalfa, bean, birch, blackberry, box-elder, buckeye, buckthorn, buckwheat, canaigre, celery, cherry, choke-cherry, clover, corn, cottonwood, currant, dahlia, elm, gooseberry, grape, grass, hazelnut, hemp, hollyhock, jimson weed, linden, maple, oak, oat, pear, plum, potato, raspberry, rhubarb, rose, snowball, sugar beet, sumach, syringa and black walnut.

Control.—The most effective time to control the apple leaf-hopper is when it is in the nymphal stage, in the spring and summer months. Kerosene emulsion and tobacco decoction ("black leaf 40," 1 pint to 100 gallons of water) give good results if applied before the leaves become curled and afford protection for the hoppers. Nursery trees may be readily cleaned by bending the twigs and dipping the infested tips in a bucket containing one of the above solutions. June and July are the best months for treatment. Sticky shields and hopper-dozers are also valuable in capturing the hoppers in nurseries. Clean culture should be practiced in the orchards and nurseries to eliminate as far as possible all weeds and grasses which serve as food plants.

Natural Enemies.—The most effective natural enemy here is the small dark bug (*Triphleps tristicolor* White), which preys upon the nymphs by puncturing their bodies and extracting the contents.

The larvæ of the green lacewings also prey upon the young hoppers.

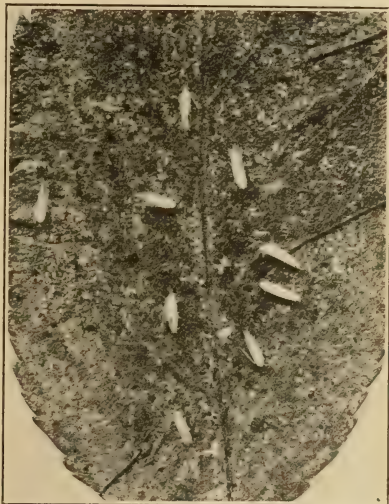



Fig. 52.—The rose leaf-hopper, *Empoa rosa* (Linn.). Adults on an apple leaf, which shows their characteristic work. (Original)

THE BEET LEAF-HOPPER

 *Eutettix tenella* Baker²⁶

(Fig. 53)

Description.—The adults are very small, pale yellowish-green or almost white. The eggs are elongated, slightly curved, tapering at one end and white. They are inserted into the leaf stems. The nymphs are pale creamy-white with darker markings on the dorsum.

Life History.—The females appear in the beet fields in June and begin egg-laying the last of the month and continue until late in August.

The eggs are usually thrust singly into the tissues of the leaf petioles, where they are often placed close together. The eggs hatch in about two weeks and the young begin to appear the first part of July and continue in evidence until September. By the last of July adults appear, in which stage the winter is passed.

Nature of Work.—The “curly-leaf” of the sugar beets is thought to be caused or transmitted by this leaf-hopper. The veins of the leaves thicken, nipple-like swellings appear on them and the leaves become severely curled and folded. In bad

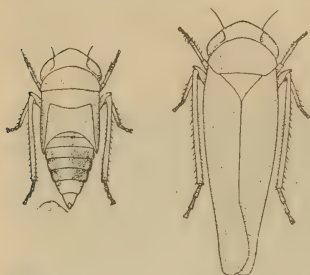


Fig. 53.—The beet leaf-hopper, *Eutettix tenella* Baker. Nymph and adult greatly enlarged. (After Ball)

cases the entire plants die, while in mild cases recovery is slow and the the quality of the beets very poor.


Distribution.—The species has been found in the central part of the State, in the southern part, at Chino, San Bernardino County,³⁷ and at San Diego County. It occurs widely over the State.

Food Plants.—Dr. Ball records the following hosts: *Atriplex*, sugar beets, Russian thistle, sea blite and *Sarcobatus*.

Control.—Control measures are somewhat difficult. The application of a dilute oil emulsion spray, to which $\frac{3}{4}$ of a pint of 40 per cent nicotine sulphate to every 100 gallons is added, will give good results if applied as soon as the young begin to appear. Low hopper-dozers will give fairly good results if used often. Early planting, to insure an early vigorous top, enables the plants to more successfully resist attacks. So far as known nothing tried has justified the cost.

THE GRAPE LEAF-HOPPER

 *Erythroneura comes* (Say)

 (*Typhlocyba comes* Say)

(Fig. 54)

Description.—The adults are very small, being scarcely more than $\frac{1}{8}$ inch long. The color is somewhat variable. During the summer they appear light yellow with the wing-covers mottled with faint red spots. As the season advances the red areas increase in size until winter, the

²⁶Ball, E. D., Bul. No. 66, pt. IV, Bur. Ent. U. S. Dept. Agric., 1909.

³⁷Ball, E. D., Bul. No. 66, pt. IV, Bur. Ent. U. S. Dept. Agric., pp. 36 and 47, 1914.

body becomes dark red. The young are white or light yellow with very faint red spots. The eggs are very small, semi-transparent, bean-shaped and about 1-34 inch long.

Life History.—According to Professor H. J. Quayle, the eggs are inserted just beneath the epidermis on the underside of the grape leaves and hatch in from fifteen to twenty days. The young nymphs begin at once to feed upon the first appearing foliage, by extracting the juices from the leaves with the sharp beaks. There are two broods a year: winter and summer. The adults of the former hibernate and begin feeding upon the first foliage in the spring. During May they begin egg-laying, which gives rise to the summer brood. This brood grows very rapidly and lays eggs within a few weeks, dying off in the fall. Their eggs give rise to the coming winter brood. Thus the destruction may begin in May and end only when all of the leaves have fallen.

Nature of Work.—The young and adult hoppers feed upon the undersides of the leaves, causing them to turn yellow or brown and to fall prematurely. In cases of severe infestation so many of the leaves may fall as to prevent the ripening of the crop.

Distribution.—This hopper occurs throughout all of the vine-growing sections of the State, and is especially abundant in the San Joaquin and Sacramento valleys.

Food Plants.—The principal and practically the only host during the summer months is the foliage of various kinds of grapes, but during the winter such low-growing succulent plants as alfalfa, clover, filaree, grasses, mustard and ragweed are attacked, while in the spring the foliage of beech, blackberry, burdock, catnip, currant, dewberry, gooseberry, grasses, maple, raspberry, strawberry and Virginia creeper become food plants.

Control.—Spraying should be done when the hoppers are in the nymphal stage, about the last of May or the first of June. A spray containing .02 of one per cent nicotine or a nicotine-soap spray ("black leaf 40," 1 pint, soap 4 pounds, water 200 gallons) gives good results if applied under from 150 to 200 pounds pressure as a coarse driving spray. Screen cages, large enough to cover a vine, with a bottom to fit around the trunk, one open side and smeared on the inside with crude oil, may be placed over the vine with the open side facing the wind. Upon jarring the vines through the slit the excited hoppers, in trying to escape, are caught in the oil on the sides and bottom. In this way large numbers are caught. To be of any value this method must be used in the spring, before egg-laying begins. Specially constructed suction devices for drawing in the hoppers by air currents have also been tried in the San Joaquin Valley, but without financial success.

Clean culture to eliminate all food plants in the vineyard and around the edges should not be neglected in the fight to control this pest.



Fig. 54.—The grape leafhopper, *Erythroneura comes* (Say). Adult female, summer form. Natural size shown by line at the right. (After Johnson)

Natural Enemies.—So far no internal parasites of this pest are known. The larvæ of the California green lacewing (*Chrysopa californica* Coq.) devour the young nymphs. Ladybird beetles also prey upon the young, but are of little consequence in the matter of control.

THE BLUE SHARPSHOOTER

♂ *Tettigoniella circellata* (Baker)

♂ (*Tettigonia circellata* Baker)

(Fig. 55)

Description.—The color of the adults varies from dark-green to deep bluish-green with bright blue markings on the head and sometimes on the wings and venter. The legs, abdomen and scutellum are light yellow or orange. The tip and base of the ventral surface of the abdomen are often blue. There are black markings on the head, thorax, scutellum and bases of the front wings, the veins of which are also black. The hind wings are smoky or black. The length averages $\frac{1}{4}$ inch. The immature forms are light green.

Life History.—The life history of this species has never been worked out for this State. The adults appear early in the spring, and continue to breed throughout the summer. The insect is quite prolific and is often responsible for much damage to crops in California.

Nature of Work.—The young and adults feed upon the foliage, extracting the juices with their small, sharp rostrums or beaks, thus causing yellow, sickly-looking plants, which are sometimes greatly weakened or stunted by their attacks.

Distribution.—The blue sharpshooter occurs throughout the State and is most abundant in the central and southern parts.

Food Plants.—This species is a very general feeder, attacking a great many plants. Among those recorded are: blackberry, elder, grape, hollyhock, lemon, orange, raspberry and sunflower. On grapevines it is sometimes more destructive than is the grape leaf-hopper.

Control.—The control measures are the same as for the grape leaf-hopper.



Fig. 55.—The blue sharpshooter, *Tettigoniella circellata* (Baker). Enlarged three times. (Original)

PSYLLIDÆ (Family)

JUMPING PLANT LICE

The adults of the members of this family greatly resemble minute cicadas and also appear somewhat like large winged plant lice. They differ from the former in having the proboscis rising from the middle of the sternum and being much smaller, and from the latter in having the hind femora greatly developed, enabling them to jump

freely. The nymphs are also characterized by having large and conspicuous wing pads. Like the plant lice they feed upon the tender foliage and bark of various plants.

THE PEAR PSYLLA

Psylla pyricola Forster³⁸

(*Psylla pyri* Curtis)

Description.—There are two distinct forms of this species, a summer and winter. The adults of the summer form are light orange to reddish in color with darker markings. The antennæ are slender and one and one-half times as long as the width of the head. The legs are slender with or without basal spurs on the hind tibiæ. The wings are transparent. The length to the tips of folded wings of the female is 1.9 inch and less for the male. The adults of the winter form are larger and darker in color, varying from dark reddish-brown to black. The length to tips of folded wings of the female is 1.6 inch and 1.7 inch for the male. The eggs are light yellow, elliptical with short pedicel at the large end for attachment and a slender projection at the small upper end.

Life History.—The eggs are deposited singly in rows of from five to ten in cracks or crevices in the bark or at the bases of the terminal buds of the previous year's growth. They are laid in April and May and hatch in from one to four weeks after deposition. The first young are light yellow with red eyes and three-jointed antennæ. When full-grown the nymphs are light yellowish brown or amber with dark wing pads and with long marginal body spines. The adult stage is reached within about a month after the eggs are laid. The last brood in the fall hibernates in the adult stage in cracks in the bark, under the bark, in rubbish, etc., and begins egg-laying in the early spring. There are four broods a year.

Nature of Work.—Due to the large numbers which may occur on a tree at one time, serious damage is often done by this insect. The leaves are curled, turn yellow and may drop, and if the attacks continue, the trees may be completely defoliated.

Distribution.—This insect was recorded as occurring in California as early as 1883 by Matthew Cooke³⁸ but no further mention of it is found in later literature. If it occurs in the State its distribution is very limited to have evaded detection for so long. Crawford in his work on "The Jumping Plant Lice of the World," page 145, doubts its existence in the State.³⁹

Food Plants.—The foliage of the pear is the only reported host in America, but in Europe the apple is also sometimes attacked.

Control.—The application of a strong winter spray of oil emulsion or miscible oil will kill many of the hibernating adults. The young and nymphs are readily destroyed by these sprays if there is added $\frac{3}{4}$ pint of tobacco extract (40 per cent nicotine sulphate) to 100 gallons. A spray composed of $\frac{3}{4}$ pint of 40 per cent nicotine sulphate, 5 pounds

³⁸Inj. Ins. Orchard, Vineyard, etc., p. 117, 1883.

³⁹Crawford, D. L., Bul. 85, U. S. Nat. Mus. pp. 144-146, 1914.

of whale oil soap and 100 gallons of water and the carbolie acid emulsion is also excellent for killing the nymphs and adults.

Natural Enemies.—The two-spotted ladybird beetle (*Adalia bipunctata* Linn.) and the green lacewing (*Chrysopa californica* Coq.) feed upon the eggs and larvæ of the pear psylla.

THE LAUREL PSYLLID

Trioza alacris Flor.⁴⁰

(Figs. 56, 57)

Description.—The adults look much like large plant lice, but jump quickly when disturbed. They are about 3-16 inch long, slender and vary from greenish-yellow to light brown. In the darker individuals the dorsum is streaked with brown. The antennæ are



Fig. 56.—The laurel psyllid, *Trioza alacris* Flor. Tip of laurel branch showing the curled leaves produced by the young cottony covered nymphs which are also present. Natural size. (Original)

about one and one-third times as long as the width of the head, slender and dark at the tips. The legs are slender with two black spines on the inside and one on the outside of the tips of the tibiæ.

⁴⁰Crawford, D. L., Bul. 85, U. S. Nat. Mus., pp. 94-95, 1914.

The wings are slender, transparent and about three times as long as broad. The young nymphs are pale green and cover themselves with a thick white cottony material. When about half-grown they are mottled light or dark brown, with conspicuous wing pads. The eggs are very minute, whitish, elliptical and attached by a slender stalk.⁴¹

Life History.—The life history of this species has not been completely worked out in California. The eggs are laid in the early spring from which the first brood develops, adults appearing in August and September. These hibernate and deposit eggs the following spring. There is but one brood a year.

Nature of Work.—The leaves of the laurels are thickened and often badly curled by the attacks of this psyllid and the tree may become unsightly and stunted by their continued feeding upon them.



Fig. 57.—The laurel psyllid, *Trioza alacris* Flor. Adults and nymphs on a laurel leaf. Enlarged three times. (Original)

Distribution.—This insect has been taken only in Alameda and San Mateo counties. It was discovered by O. E. Bremner and identified by D. L. Crawford, who first published relative to its occurrence in the State.⁴¹ The writer took quantities of the nymphs and adults at Melrose, Oakland, Cal., in August. They were a decided menace to the infested trees and much spraying and other control measures were being employed to diminish the attacks. It is common in Europe

⁴¹Crawford, D. L., Mo. Bul. Cal. Hort. Com., Vol. 1, pp. 86-87, 1912.

and has probably been shipped into many parts of the State along with the laurel trees.

Food Plant.—The laurel (*Laurus nobilis*) is the only recorded host.

Control.—Control measures are same as for the pear psylla.

APHIDIDÆ (Family)

PLANT LICE

The members of this family comprise one of the most important groups of destructive insects. Every one is familiar with the soft-bodied winged and wingless plant lice which gather so abundantly upon all sorts of plants. The beak or proboscis appears to rise in the middle of the sternum, the legs are rather long and slender; the wings when present, are membranous, with few veins and when at rest are, except in a few cases, held roof-like over the abdomen. Many of the females of this family have the power of producing living young without sexual intercourse, and are usually called viviparous or agamic females. True sexual forms usually appear some time during the life-cycle. Winged or migratory forms also occur. Some species live almost entirely underground while others are aerial in habits. As this family plays such an important part in the rôle of insect pests, we are including a large number of the most common species.

Control.—The treatment for insects which are both aerial and subterranean in habits naturally calls for entirely different methods for each form. Of the plant lice two species stand out as splendid examples of the subterranean form. They are the woolly apple aphid and the black peach aphid, but both of these have aerial generations.

METHODS FOR CONTROLLING UNDERGROUND FORMS

Prevention.—In setting out a young orchard one of the first things to consider is how to prevent the introduction of certain serious pests and diseases which may be carried on nursery stock. Both the black peach aphid and the woolly apple aphid are easily distributed on young trees. The following precautions should be taken in setting out any new peach, apple or pear orchard:

1. Set out clean stock. Do not buy trees which have the roots puddled unless the mud is washed off—it may hide the insects and such infested trees would be severely handicapped and not worth planting.

2. The woolly apple aphid does very little damage to the Northern Spy; especially is this true regarding the attacks on the roots, therefore, if possible, buy apple trees grafted on Northern Spy roots, especially if your section is troubled with this pest.

3. Set trees fairly deep and keep the soil thoroughly cultivated so as to get the roots down as far as possible. The woolly apple aphid seldom works lower than ten inches below the surface.

Sprays.—Before making applications around the crown of the tree for the control of root forms, first remove the earth around the roots to a depth of six or seven inches and a distance of two or three feet

from the crown. Use two or three gallons of liquid per tree, spraying thoroughly on the exposed roots. When the liquid is nearly all soaked into the soil cover up the basin. The materials which have given the most satisfaction follow:

Tobacco Leaves.—Place in the bottom of the excavation dry tobacco leaves to the depth of one half or one inch and replace the soil. The action of the moisture on the tobacco will carry the nicotine thus extracted to the lice and kill a great many if not all. The use of tobacco leaves in this manner does not injure the trees.

Tobacco Decoctions.—The floor of the excavation may be thoroughly sprayed with a very liberal application of a tobacco decoction composed of one part "black leaf 40" (40 per cent nicotine sulphate).

Carbon Bisulfid.—In light sandy, but not too porous soils, carbon bisulfid is used very effectively. The treatment should be made early in the spring, about April, as follows: make four or five holes eight inches deep in a radius of eighteen inches or two feet from the tree. Into each pour from 3 to 4 liquid ounces of carbon bisulfid, and immediately cover the hole. See that the liquid does not come in contact with the roots, as it is likely to kill them.

Tanglefoot Bands.—If the dormant trees are sprayed with a strong solution of kerosene emulsion or lime-sulphur just before the buds open in the spring, it is well to put a tanglefoot band around the trunks to keep root forms from migrating to the tops.

METHODS FOR CONTROLLING THE AERIAL FORMS

The sprays used in controlling the aerial forms (those infesting the bark, fruit and foliage) may be arranged under the two following heads—winter sprays and summer sprays:

Winter Sprays.—In order to destroy the wintering eggs deposited upon the branches in the fall by the sexual females it is necessary to apply strong sprays during the winter from November to March when the trees are dormant and able to stand such solutions. By killing the eggs the next season's broods may be greatly reduced. For this purpose the miscible oils⁴² and oil emulsions are specially adapted and give best results. The spraying must be thoroughly done in order to completely drench the tops and tips of outside twigs which are favorite places for egg-laying.

Summer Sprays.—During the summer, when the trees are in foliage, much weaker sprays must be used to avoid burnings. Various formulæ of nicotine and tobacco sprays appear to be most satisfactory. The two following formulæ are specially recommended:

A. ⁴³ Black leaf 40 (nicotine sulphate)	3	ounce
Soap	4	ounces
Water	4	gallons

Dissolve the soap in hot or boiling water; add the "black leaf 40" and boil for a few minutes, after which add enough water to make four gallons of prepared material.

⁴²The formulæ for all sprays are given in the chapter on sprays near the back of the book.

⁴³Parker, J. R., Cir. No. 28, Mont. Agrcl. Exp. Sta., 1913.

B. ⁴⁴ Black leaf 40-----	1 pound
Cresol soap (liquid)-----	1 gallon
Water-----	200 gallons

This mixture is a very efficient spray and a coming favorite for many pests because of this and its simplicity of preparation. The spray tank is filled with water and the "black leaf 40" and liquid cresol soap are added cold and only a brief agitation is necessary before the material is ready to be applied. It is specially effective against the woolly apple aphid or any cottony-covered plant louse and even better for the unprotected species.

Other sprays which may be used with fair success are carbolic acid emulsion, resin wash and oil emulsions, but all of these are improved by the addition of 1 part of black leaf 40 to 1000 parts of the diluted sprays.

Natural Enemies.—There are many insects preying upon the soft-bodied and almost wholly unprotected plant lice. The most common predaceous ones belong to the three families, *Coccinellidæ* (ladybird beetles), *Chrysopidæ* (green lacewings) and *Syrphidæ* (syrphid flies). Large numbers of other insects also prey upon the plant lice, but are too numerous to mention here.

Many minute hymenopterous parasites also work upon aphids and the mummied bodies of the latter with circular holes in the backs are evidences of their execution. Under the discussion of *Hymenoptera* their efficiency and methods of work are more fully given.

Fungous diseases kill many of the lice, especially during the early spring, when there is much moisture.

THE GRAPE PHYLLOXERA

Peritymbia vitifoliæ (Fitch)

(*Phylloxera vastatrix* Planchon)

Description.—The presence of this pest is usually manifested by its work, which consists in the formation of rough, wart-like galls upon the leaves and small knots upon the roots. The lice producing the galls are very small and orange-colored. White eggs as well as the young are also to be found within the galls which, however, are seldom seen in California.⁴⁵ The root lice are about 1-25 inch long and greenish-yellow in summer and a little darker in winter.

Life History.—During the months of July and August some of the eggs laid by the females of the root forms hatch into individuals which acquire wings. These seek the foliage of the vines and lay large eggs which produce true females, and small eggs which produce males. These sexes mate and each female lays a single winter egg upon the bark of the two-year old wood. In the spring these eggs hatch into a root form (or gall-making form) which produce the root-feeding forms in other stages, which in turn lay eggs giving rise to the many summer generations of devastating root aphids. In

⁴⁴Woodworth, C. W., Cir. No. 102, Cal. Agrel. Exp. Sta., 1913.

⁴⁵The gall stage on the leaves is generally omitted in the life history of this louse in California.

California the latter hibernate on the roots and may continue for at least four years without reverting to the sexual forms.

Nature of Work.—In this State the first symptoms of the presence of phylloxera are the gradually dying vines in certain areas or throughout the vineyard. These dying areas are usually enlarged every year. An examination of the small roots will reveal small bead-like swellings and perhaps some of the minute plant lice themselves, but the swellings on the roots are the most characteristic injuries produced by this insect. In the Eastern States the rough wart-like galls upon the leaves are even a more noticeable work of the phylloxera.

Distribution.—While this pest has been supposed to be limited to the central portions of the State, its appearance in the north seems to indicate that it occurs to some degree in most grape-growing sections north, and one place south, of the Tehachapi.

Food Plants.—This insect feeds upon practically all varieties of grapevines, but is most damaging to the European varieties. Many cultivated varieties and hybrids as well as wild species are slightly attacked, but not so as to greatly impair their vitality and growth. These latter are known as resistant vines and are important factors in the selection of roots for vines set out in phylloxera-infested districts. The main source of injury is due to the attacks upon the young and vigorous roots which are completely destroyed. The roots of the so-called "resistant stock" do not materially suffer from such attacks.

Control.—By far the most important method of control is the use of resistant root-stocks upon which are grafted the desired varieties. Of course, care must be exercised in selecting stock for the various varieties and expert advice obtained before making extensive selections or plantings.

Direct remedies for infestations are unsatisfactory. Flooding the vineyards, if the water can be held for a month, will almost exterminate the pest, if done in the winter, but such a method is impracticable in most of the grape-growing sections of the State.

Carbon bisulfid is an efficient remedy in sandy soil, but in such places the pest is usually less abundant.

COOLEY'S CHERMES

Chermes cooleyi Gillette

[*Gillettea coweni* (Gillette)]⁴⁶

(*Chermes cooleyi coweni* Gillette)⁴⁷

(Fig. 58)

Description.—The presence of this louse is plainly indicated in the spring of the year by the many small tufts of white, cottony material which cover the small bodies of the individual females resting on the needles of the food plants. The hibernating females or stem-mothers are exceedingly small, very dark green or black with a fringe of white,

⁴⁶Zol. Anz., XXXIV, p. 498.

⁴⁷Gillette, C. P., Proc. Acad. Nat. Sci. Phil., pp. 10-14, 1907. The description and life history were taken from Professor Gillette's paper. In a recent letter he has informed the writer that he considers all of the above only forms of the same species.

waxy threads around the margin and a row down the middle of the dorsum. The antennæ are three-jointed. In the spring (April) the entire body is covered with the white cottony material, as shown in Fig. 58. At this time the color changes to a reddish-brown. Fully-mature specimens vary from 1-30 to 1-25 inch and three fourths as wide. The eggs are oval and light yellow. The pupæ are first rusty-brown, becoming darker with age. The dorsum is covered with white powder and dark, glandular spots. On the abdomen there are six longitudinal rows of these glands from which the cottony covering is secreted. The winged females are also reddish-brown with black head and thorax and dusky five-jointed antennæ and legs. The bodies are covered with rather dense white cottony threads, allowing only the wings to show.

They are about the same size as the full-grown apterous females.

Life History.—The winter is spent by the small females or stem-mothers on the surface of the needles of the red fir or the Douglas spruce. In the spring these females begin to grow and cover the bodies with white, cottony wax and to secrete quantities of honey-dew. About the middle of April or earlier they begin to lay eggs, each depositing from twenty-five to forty.

These hatch in about two weeks and the young settle and feed on the new and tender tips of the twigs. They mature into winged and apterous females. The apterous forms deposit eggs which hatch into hibernating females, while the winged forms migrate to the silver spruce and lay eggs which hatch very quickly. The young of these settle on the tender needles at the tips and cause large light-green or purplish galls which may be from $1\frac{3}{4}$ to 2 inches long. About the middle of July those on the silver spruce become full-grown winged migrants which fly to the red fir or the Douglas spruce and lay eggs which hatch also into hibernating females. Professor Gillette states that "It is certain that the forms on the Douglas spruce are the descendants of the migrants from the silver spruce, and it is equally certain that the gall producing forms on the silver spruce are the immediate descendants of the winged migrants from the Douglas spruce."



Fig. 58.—Cooley's Chermes, *Chermes cooleyi* Gillette. Young females covered with white cottony wax on the needles of Douglas spruce. Natural size. (Original)

The life history has not been worked out in California. In the spring of the year and during the summer females have been found on the Douglas spruce, but the gall-producing form has not been observed.

Nature of Work.—Though trees are never killed by the attacks of the lice, they often appear stunted and very unsightly because of the large amount of honey-dew over which the black fungus grows. Characteristic terminal galls are also formed on the twigs of the silver spruce, as stated above.

Distribution.—The *Chermes* are not at all common in this State. This species is most often met with and occurs throughout the central and northern parts of the State, principally in parks and gardens. It is quite abundant in the San Francisco Bay region, especially in San Francisco, San Mateo and Santa Clara counties.

Food Plants.—Professor Gillette records the following hosts in Colorado: The red fir (*Abies magnifica*), Douglas spruce and silver spruce (*Picea parryana*). W. M. Davidson has taken it on the false spruce (*Pseudotsuya douglasii*) at Stanford University.⁴⁸ The writer has collected it on the Douglas spruce in the Golden Gate Park, San Francisco, where it has also been repeatedly taken by Mr. Harold Compere.

Control.—The best control measures consist in the application of miscible oil, crude oil emulsion or carbolic acid emulsion sprays during the winter months when the insects are in an immature condition and lack the waxy covering.

THE BEET ROOT APHIS

Pemphigus betæ Doane

Description.—The adult wingless aphid is about $\frac{1}{8}$ inch long, somewhat rounded or elongated in shape, whitish or pale yellow in color, with a large tuft of white flocculence covering the tip of the abdomen. The legs, antennæ and spots on the top of the head are brown. The winged louse is a little larger, more elongated and much darker in color. The head, antennæ, legs and thorax are black and are usually covered with a fine, white powder, appearing bluish-black. The abdomen is dark green. The presence of this pest is easily told by the white flocculence which covers the bodies.

Life History.—Most of the wingless, viviparous females feed upon the tubers of beets and roots of weeds and other plants during the summer. In the fall, winged migrants fly to cottonwood trees and give birth to true sexual males and females, which mate and each female deposits a single winter egg in the crevice of the bark, which does not hatch until the following spring. The young lice hatching from these eggs, about the time the leaves appear in the spring, are known as stem-mothers. They settle upon the leaves and according to Professor Gillette do not produce a gall but fold the leaves in which the first generation of young are reared. The migrants from the cottonwoods fly to the fields and infest beets and other plants and give rise to the summer apterous and winged forms, some of the

⁴⁸Jr. Ec. Ent., III, p. 372, 1910.

latter of which later fly back to the cottonwood trees to produce sexual forms which mate and the females lay the overwintering eggs.

Distribution.—This species is widely distributed throughout the State.

Food Plants.—This plant louse often infests roots in such a way as to ruin portions of a crop. Sugar beets are the only economic plants attacked to any injurious degree. Cottonwood, dock, fox-tail grass, knotweed, lambsquarters and yarrow may also become infested.

THE POPLAR-STEM GALL-LOUSE

Pemphigus populicaulis Fitch⁴⁹

(Fig. 59)

Description.—The stem-mother is slightly green or yellow, covered with distinct rows of small cottony patches, $\frac{1}{8}$ to $\frac{1}{4}$ of an inch long and nearly as wide. The winged female is much smaller, dark in color and covered with fine wax and long white flocculence.



Fig. 59.—The poplar-stem gall-louse, *Pemphigus populicaulis* Fitch. Winged female and stem-mother. Greatly enlarged. (Author's illustration, P. C. Jr. Ent.)

Life History.—The stem-mother starts the peculiar gall on the stem at the base of the leaf, and produces young until the large gall is completely filled. So tightly closed is the entrance of the gall that few, if any, parasites can gain entrance. When the inhabitants are ready to migrate in the summer a distinct opening is made, through which they escape readily. These feed upon other plants and late in the fall migrants fly to the cottonwood trees where the sexual forms are born and the females of which lay the overwintering eggs on the bark. These hatch into the stem-mothers referred to above.

Distribution.—This louse occurs throughout the State, wherever the host plants are found.

Food Plants.—Common cottonwood (*Populus trichocarpa*), *P. monilifera* and aspen are attacked. The Lombardy poplar appears to be immune according to Davidson.

Natural Enemies.—This species is preyed upon by internal parasites in late summer, but is more often attacked by a small bug belonging to the family *Anthocoridae*.

⁴⁹The galls of the transverse poplar-stem gall-louse, *Pemphigus populitransversus* Riley, resembles those of this species, but may be distinguished by the transverse slit in the side.

THE BEAD-LIKE COTTONWOOD GALL-LOUSE

Tecabius populimonilis (Riley)*(Pemphigus populimonilis* Riley)

Description.—The body is dark and covered with rather long white flocculence, which gives it a bluish appearance. The presence of this species is easily told by the very characteristic reddish, bead-like or almond-shaped galls formed on the margins and centers of the leaves of the cottonwood trees which it infests.

Life History.—According to Professor C. P. Gillette⁵⁰ the eggs are probably laid on the cottonwood trees in the fall and hatch the following spring into the stem-mothers. These settle on the young leaves between the midrib and the margin and produce almond-shaped or bead-like galls. The young from the stem-mothers also locate on the tender leaves and cause similar galls. Nearly all of these are winged and many migrate to other leaves and trees, there being a third generation arising from the winged forms whether they migrate or remain in the original galls. In the latter case as many as twelve young may be found in a gall with the parent. These young mature in the fall and give birth to the sexual forms, which mate and the females lay the overwintering eggs. The sexual females are pale green and the males yellow. Neither have rostrums or beaks for feeding.

Distribution.—This species occurs throughout the State, wherever the host plants grow, but appears to be more abundant in the southern part.

Food Plants.—The common cottonwood (*Populus trichocarpa*), *Populus fremontii*, *P. balsamifera* var. *angustifolia*, are attacked.

THE SOLANUM ROOT PLANT LOUSE

Trifidaphis radicicola (Essig)*(Pemphigus radicicola* Essig)

Description.—The apterous female is distinctly globular in shape and varies from amber to cream-color and often has a fine, white, powdery covering. The winged form is amber with dark head and thorax. The wings are dusky. The length varies from 1.25 to 1.12 inch.

Life History.—This species is subterranean in habits and is evident during the early spring and the entire summer. The winged form appears in July and August. It has not been determined whether the species hibernates in the egg stage or as viviparous females or as both.

Distribution.—This species occurs throughout the central and southern parts of the State and is especially abundant in the south.

Food Plants.—Roots of nightshade (*Solanum douglasii*), pigweed, and potato tubers are attacked. The alternate host has not been discovered.

⁵⁰Ann. Ent. Soc. Am., VI, No. 4, pp. 485-492, 1913.

THE BLACK CITRUS PLANT LOUSE

Toxoptera aurantiæ Koch

(Fig. 60)

Description.—This is a small dull-black plant louse, scarcely over 1-16 inch in length. The apterous forms often appear brown, while the young are a decided reddish-brown to black. Some of the adults are somewhat shiny black and have been mistaken for the black peach aphid (*Aphis persicæ-niger*). It is easy to distinguish the winged individuals of this species by the very dark and prominent stigma and the single branch of the third discoidal vein.



Fig. 60.—The black citrus plant louse, *Toxoptera aurantiæ* Koch. Winged and apterous females. Greatly enlarged. (Author's illustration, P. C. Jr. Ent.)

Life History.—This species may be found in the citrus groves throughout the entire year, all stages being present. The greatest numbers occur during the spring months, when all the new growth may be destroyed on the young trees by them. Older trees are also attacked. The presence of the insects on the larger and older leaves is easily told by their curled appearance, a condition produced by the plant lice. The eggs have not been observed but they are probably laid on the citrus trees in the late fall.

Distribution.—This aphid occurs throughout the entire citrus growing section of the State. It is especially abundant in the southern coast counties.

Food Plants.—This pest attacks camellia, citron, coffee, grapefruit, lemon, *Olea straussia*, orange and tangerine.

Natural Enemies.—This insect would be a far greater pest were it not for its many natural enemies. Two internal parasites, *Aphidius testaceipes* Cr. and *Charips xanthopsis* (Ashm.), have been bred from adult plant lice, while the California ladybird beetle (*Coccinella californica* Mann.) and the larvæ of three syrphid flies (*Allograpta obliqua* Say, *Syrphus americanus* Wied. and *Syrphus pyrastris* Linn.) have been observed in large numbers feeding upon it. The second internal parasite is probably secondary.

THE WOOLLY APPLE APHIS

Eriosoma lanigera (Hausmann)(*Schizoneura lanigera* Hausmann)

(Fig. 61)

Description.—To the average orchardist this insect is of too common occurrence to need any suggestions for its identification. The dark red or purplish louse covered with the long white cottony wax or floccu-

lence is the most serious apple pest in many of the northern counties. The winged forms are distinguishable by their dusky protruding wings. The fall and early winter lice are dark yellowish or brown in color.

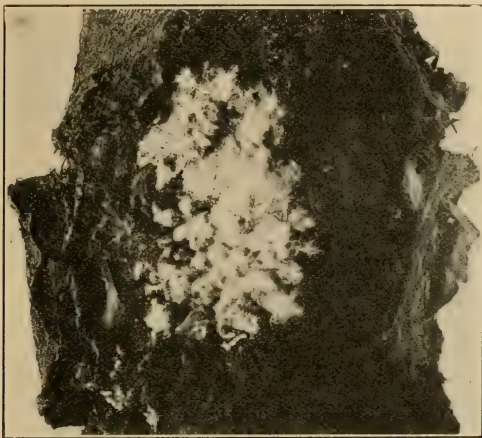


Fig. 61.—The woolly apple aphid, *Eriosoma lanigera* (Hausm.), on apple twig. Enlarged twice. (Original)

Life History.—In summer, especially during the months of July and August, the woolly apple aphid is exceedingly abundant upon the limbs of the trees, covering large patches with their extensive colonies. Towards winter it gradually disappears, only a few individuals remaining hidden under protecting bark or in crevices. In the fall each winged viviparous female gives birth to five or six males or females which mate, each female laying a large egg which constitutes the over-wintering form.

In the spring the over-wintering eggs hatch into stem-mothers, which give birth to young. These mature in about ten days and continue to repeat the process of bringing forth living lice until thousands appear upon the trees. The succeeding broods attack both the limbs and roots throughout the summer and fall. Probably some of the viviparous females pass the winter on the roots in our mild climate. There are probably also alternate hosts, as shown in the investigations of Dr. Edith M. Patch of the Maine Agricultural Experiment Station.⁵¹

Nature of Work.—The large knots are produced upon the limbs and roots by this aphid. These enlargements prove serious handicaps to the growth of the trees, so that both old and young ones are unable to grow normally or produce good crops when infested.

Distribution.—This species occurs in practically every section where apples are grown in the State.

⁵¹Bul. No. 220, Maine Agrcl. Exp. Sta. Nov. 1913.

Food Plants.—The apple is the favorite food of this insect, though it also feeds quite extensively upon the roots of pear trees. The old limbs, young shoots, suckers and roots are attacked. Characteristic knots are produced upon the shoots and others somewhat different upon the roots. Upon the older limbs great rough enlargements appear, which become nearly a foot in diameter and look considerably like a burl. In these many of the lice spend the winter.

There is considerable difference in the attacks upon the varieties of the apple. The Northern Spy is practically immune, and for this reason is much sought after as a resistant root-stock for grafting purposes. Vigorous growing varieties, such as the Rhode Island Greening and Bellflower, are very much injured. In some sections the former is decidedly undesirable because of the great injury thus received. Practically all other commercial varieties are affected in a greater or less degree, the King of Tompkins County being injured the least in the north.

In a large number of localities throughout the State Mr. G. P. Weldon has found the roots of the pear also seriously infested.

Natural Enemies.—Several insects prey on the woolly apple aphis, but are not an economic factor in the control of this pest.

THE ARBORVITÆ PLANT LOUSE⁵²

Lachnus thujaefalinus Del Guercio

(Fig. 62)

Description.—The adults of this louse are amber-brown with the dorsum partially covered with fine whitish powder, definitely arranged as shown in Fig. 62. The antennæ, legs and cornicles are marked with black. The winged forms have dark head and thorax. In the apterous forms, especially, the head is very narrow and the body widest across the abdomen. The entire surface is covered with quite long, fine hairs.



Fig. 62.—The arborvitæ plant louse, *Lachnus thujaefalinus* Del Guercio. Enlarged five times. (Author's illustration, P. C. Jr. Ent.)

Distribution.—The distribution is quite wide and the insect may be found almost anywhere the host plant occurs throughout the State.

Food Plant.—The cultivated arborvitæ (*Thuja occidentalis*) is the only recorded host. The lice feed on the bark of the branches.

⁵²In the author's previous writings this species has been referred to as the juniper louse, *Lachnus juniperi* De Geer.

THE MOTTLED COTTONWOOD PLANT LOUSE

Thomasia populicola (Thomas)*(Chaitophorus populicola* Thomas)

(Fig. 63)

Description.—The adult is dark red or wine-colored, often appearing nearly black, and is distinguished from other poplar plant lice by the clouded wings. The winged form is much darker than the apterous, which is distinctly robust and characterized by a yellow blotch on the back, not unlike an inverted "Y." This species clusters in great colonies at the tips of the young shoots.

Nature of Work.—The leaves and petioles become sticky with honey-dew upon which the black soot fungus grows. The entire tree may also become very unsightly because of this.

Distribution.—This pest occurs throughout the entire State wherever the food plants grow.

Food Plants.—The common cottonwood (*Populus trichocarpa*) and other poplars, including *Populus fremonti*, and willow become infested with this louse.

Natural Enemies.—This plant louse is attacked by many natural enemies, chief of which is the native ladybird, *Scymnus nebulosus* Lec.



Fig. 63.—The mottled cottonwood plant louse, *Thomasia populicola* (Thos.). Apterous female. Greatly enlarged. (Author's illustration, P. C. Jr. Ent.)

THE MONTEREY PINE APHIS

Essigella californica (Essig)*(Lachnus californicus* Essig)

(Fig. 64)

Description.—The mature aphis is noticeably long and slender, light green with dark markings, minute red spots on the dorsum and very long hind legs. The average length is about 1-16 inch.

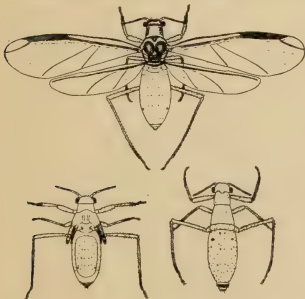


Fig. 64.—The Monterey pine aphis, *Essigella californica* (Essig). Winged female, nymph and apterous female. Greatly enlarged. (Author's illustration, P. C. Jr. Ent.)

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Life History.—So far as known all stages are passed on the pine trees where the lice are not abundant until the middle of summer, although specimens have been taken in the winter.

Distribution.—This species occurs throughout the State.

Food Plant.—This plant louse attacks the Monterey pine and yellow pine, feeding on the needles, around which it clasps its long hind legs for support.

THE WALNUT PLANT LOUSE⁵³*Chromaphis juglandicola* (Kaltenbach)(*Lachnus juglandicola* Kaltenbach)

(Fig. 65)

Description.—The presence of this plant louse is usually manifested by the smutting of the walnut trees during the early summer months. Close examination, especially of the undersides of the leaves will reveal the minute, light yellow aphids. When magnified the winged individuals will be found to have black markings on the antennæ, the middle and hind femora, and on the abdomen. The true sexual, wingless females have two distinct broad black bands across the body. The eggs are shiny black, oval and very small.



Fig. 65.—The walnut plant louse, *Chromaphis juglandicola* (Kalt.). Winged agamic female to left and nymph of same to right, apterous sexual female in middle. Greatly enlarged. (Author's illustration, P. C. Jr. Ent.)

Life History.—The sexual females deposit eggs upon the branches in the fall. These hatch in the spring (February and March) and give rise to great numbers of young which follow. The growing lice excrete a large amount of honey-dew which covers the foliage and ground beneath the tree. This honey-dew is responsible for the smutting which is sure to appear wherever the attacks occur. Late in July and in August the numbers gradually diminish and when the leaves begin to fall only the freshly laid eggs remain upon the branches.

Nature of Work.—The plant lice settle upon the first tender shoots and later upon the undersides of the leaves which are occasionally slightly curled. They also attack the young nuts. All secrete quantities of honey-dew which covers the trees and upon which a black

⁵³Key to the species of aphids attacking walnut trees in California. (From W. M. Davidson, Bul. No. 100, U. S. Dept. Agric., Aug. 31, 1914).

- a. Cornicles quite evident, about as long as long.....*Chromaphis juglandicola* (Kalt.)
- Cornicles barely perceptible, considerably wider than long.....b
- b. Tibiæ of winged viviparous female entirely dusky.....*Callipterus californicus* Essig
- Tibiæ of the winged viviparous female for the most part pale.....c
- c. Filament of joint VI longer than joint VI; oviparous female with four longitudinal rows of capitate hairs.....*Callipterus caryæ* (Monell)
- Filament of joint VI shorter than joint VI; oviparous female with six longitudinal rows of capitate hairs.....*Monellia caryella* (Fitch)

The little hickory aphid, *Monellia caryella* (Fitch) occurs in the central part of the State. It attacks the California black walnut (*Juglans californica*), hickory, bitter-nut (*Carya cordiformis*).

The American walnut aphid, *Callipterus caryæ* (Monell) has been collected in the central part of the State by Mr. Davidson and is recorded as attacking the eastern black walnut (*Juglans nigra*), hickory and pecan.

(Neither *californicus* nor *caryæ* can rightfully be placed in the genus *Monellia*. See footnote 54).

smut fungus grows. This gives the trees a very unhealthy appearance and doubtless interferes with the respiration. Much damage is claimed by walnut growers to have been caused by this aphid during the past few years.

Distribution.—This species occurs throughout the central and southern parts of the State.

Host Plant.—So far as known it works only upon the English walnut.

Special Control.—The application of commercial lime-sulphur (1 to 20) during the winter months from November to March to kill the eggs has given very good results. A woodland nozzle and high pressure are most satisfactory, though with care the work may be done with an ordinary power outfit. A summer spray composed of a 2 per cent distillate oil emulsion to which is added one part of 40 per cent nicotine sulphate ("black leaf 40") to every 1500 parts of the emulsion, has also given good results.

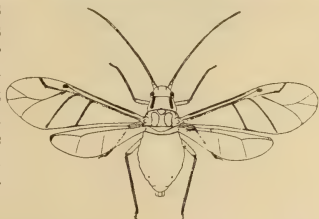
Natural Enemies.—The most effective natural foe of this louse is the ash-gray ladybird beetle, *Olla abdominalis* (Say).

THE WILD WALNUT PLANT LOUSE

Callipterus californicus Essig⁵⁴

(Fig. 66)

Description.—This louse is often confused with the walnut plant louse (*Chromaphis juglandicola* Kalt.), which is so troublesome in the walnut orchards of southern California. The difference in markings of the winged females easily separates the two lice. All of the adult females appear to be winged, the young nymphs being the only apterous individuals observed. The adult is bright yellow in color with antennæ, a band on each side of the prothorax, the wing veins, the tibiæ and feet dark. None of these markings are pronounced in the young.



Life History.—The life history of this plant louse is practically the same as for the walnut plant louse.

Fig. 66.—The wild walnut plant louse, *Callipterus californicus* Essig. Apterous female. Greatly enlarged. (Author's illustration, P. C. Jr. Ent.)

Distribution.—This species occurs in great numbers upon the wild black walnut throughout the southern part of the State.

Food Plant.—The plant lice work upon the undersides of the leaves of the California black walnut (*Juglans californica*). Great colonies may often appear so as to completely cover the foliage and the amount of honey-dew secreted is sufficient to cause smutting, rendering the trees very unsightly.

⁵⁴Mr. J. J. Davis has called attention to the fact that only *caryella* (Fitch) is included in the genus *Monellia*. In this genus the wings are folded horizontally over the back, which excludes the above species as well as *carya* Monell.

THE BAMBOO PLANT LOUSE

Myzocallis arundicolens (Clarke)(*Callipterus arundicolens* Clarke)

(Fig. 67)

Description.—The adult plant louse is about 1-10 inch long and pale yellow in color. Microscopic examination reveals the facts that the



Fig. 67.—The bamboo plant louse, *Myzocallis arundicolens* (Clarke). Winged female. Greatly enlarged. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

antennæ, the sides of the thorax, two rows of tubercles on the abdomen; the wing veins and feet are light brown or dusky. The young forms show little or no markings. Apterous females have not been observed.

Distribution.—This pest is usually found wherever the bamboo is grown. It has been collected at Berkeley, Santa Barbara, San Francisco and Sacramento and probably occurs very generally over the central and southern parts of the State.

Food Plant.—The lice feed upon the undersides of the leaves or blades of bamboo, often collecting in large colonies and doing much damage by weakening the plants and causing a smutting of the foliage.

THE MEALY PLUM PLANT LOUSE

Hyalopterus arundinis (Fabricius)(*Aphis arundinis* Fabricius)(*Aphis prunifoliae* Fitch)

(Fig. 68)

Description.—The wingless plant lice are light green with three darker green, longitudinal stripes on the dorsum, which may be lacking in some individuals. The body is long and quite narrow and entirely covered with a fine white, powdery wax, giving it a mealy or frosted appearance and accounting for the common name. The honey-tubes are pale, short and slightly constricted at the base; the eyes are dark. The winged form has a dark thorax and transverse bands on the abdomen. The eggs are oblong and shining black.

Life History.—The eggs are laid upon the fruit trees in the fall by true sexual females. They hatch into the stem-mothers in the early spring as the buds are beginning to open. The first generation soon appears and settles upon the undersides of the leaves. There seem to be no winged forms in this first brood, but later they appear in great numbers and migrate to other plants, where new colonies are started. During the summer many of the winged forms leave the trees and go to other plants and do not return to the trees until late in the fall, when the sexual forms are born and later the over-wintering eggs are laid. In Colorado Prof. C. P. Gillette has found the common reed (*Phragmites vulgaris* (*communis*))⁵⁵ to be the alternate summer host.

⁵⁵Bul. 133, Col. Agrcl. Exp. Sta. p. 40, 1908.

This has just recently been proven true for California also. Mr. Geo. P. Weldon has received specimens of the common reed from Lassen County in August badly infested with this louse. There are several broods a year.

Nature of Work.—The plant lice settle in great numbers upon the undersides of the leaves, often entirely hiding the surface and causing them to curl and droop and thus greatly reducing the vitality of the trees. Much honey-dew is also secreted, causing the growth of black smut.

Distribution. — This aphid is specially abundant in the central and northern parts of the State, where prune raising is most important. It has never been reported from the southern part of the State, though it may occur there unobserved.

Food Plants. — The plum and prune are the normal hosts of this louse in California. The common reed (*Phragmites vulgaris*) is the alternate summer host wherever this plant louse is known to occur.

Control.—Fortunately the attacks of the mealy plum plant louse are spasmodic and are of short duration, seldom requiring control measures. However, it is sometimes advisable to use remedies and tobacco decoction, and other sprays recommended for the green apple aphid should be applied in such cases.

Natural Enemies.—The larvæ of the green lacewing (*Chrysopa californica*), of ladybird beetles and of syrphid flies play a very important part in keeping down the numbers of this insect.



Fig. 68.—The mealy plum plant louse, *Hyalopterus arundinis* (Fab.), on the underside of a prune leaf. Enlarged twice. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

THE OAT APHIS⁵⁶*Aphis avenæ* Fabricius⁵⁷(*Siphocoryne avenæ* Fabricius)(*Aphis annæ* Cestlund)(*Aphis fitchii* Sanderson)

(Fig. 69)

Description.—The wingless, viviparous females, which are common during the spring and summer, are yellowish or dark olive-green, often with a mottled effect on the dorsum and with orange-colored areas around the bases of the cornicles. The latter markings are usually present only in the spring forms. The winged viviparous females or migrants are olive-green with black head, thorax, antennæ and honey tubes, black spots on the sides of the abdomen in front of the honey tubes, and the characteristic orange spots at the bases of the latter. The young of the wingless and winged forms are light green with the orange-colored areas at bases of cornicles very distinct. The egg-laying females, occurring upon the trees in the fall, are pale yellowish-green or orange-colored with conspicuous orange or pinkish spots at base of cornicles. The males occurring with the egg-laying females are of the same color, smaller and have wings. The eggs are first light green, but soon become shining black.



Fig. 69.—The oat aphid, *Aphis avenæ* Fab. Greatly enlarged. (Author's illustration, P. C. Jr. Ent.)

Life History.—The winter is spent either in the egg stage, around the buds and upon the smaller twigs of trees, or as often the case in California as viviparous females on the roots or stems of grasses. Those hibernating on the grasses are the viviparous females which give rise to the generations of viviparous wingless females and winged migrants so common throughout the late spring and entire summer. The eggs hatch into stem-mothers in the spring and these give birth to viviparous females which also produce the common summer forms. In the fall the migrants or winged viviparous females leave the grasses, weeds, etc., and seek fruit or other trees where they give birth to the true sexual males and females which mate, and the lat-

⁵⁶This species has also been known as "The European Grain Louse."

⁵⁷Much of the information contained in this description is derived from Bul. No. 112, U. S. Dept. Agric., Aug. 1914, by Mr. John J. Davis.

ter lay the over-wintering eggs. Except that some of the viviparous females pass the winter on grasses, and the fact that they migrate from the trees to the grasses in late spring thus vacating the trees during the summer months, the life history of this aphid greatly resembles that of the green apple aphid.

Nature of Work.—The aphid works upon the stems and leaves of grains and grasses, often doing very serious damage. In Imperial County the barley crop is sometimes practically destroyed in certain fields by a plant louse supposed to be this species. The leaves of fruit trees are curled similar to the work of the green apple aphid.

Distribution.—The oat aphid is generally distributed throughout the State.

Food Plants.—Apple, barley, blue-grass (Kentucky and Canada), brome grass, burdock, cat-tail, celery, cheat, upright chess, choke-cherry, wild black cherry, corn, broom corn, crab-grass, dogwood, fescue grass, hawthorn, Johnson grass, Kœler's grass, meadow grass, melic grass, oat, oat-grass, orchard grass, pear, plum, quince, rescue grass, redtop grass, reed canary grass, rye, Italian rye grass, wild rye (*Elymus canadensis* and other species), shepherd's purse, sorghum, tickseed, timothy and wheat are among the recorded food plants of the oat aphid.

Natural Enemies.—An internal parasite (*Aphidius testaceipes* Cr.), the larvæ of the American syrphid fly (*Syrphus americanus* Wied.) and various ladybird beetles prey extensively upon this aphid in California.

Control.—Because of the extensive attacks of this aphid in grain fields, the ordinary methods of control are not always practical. Spraying as recommended at the beginning of the chapter may be used on fruit and other trees and to some extent in the grain fields. In the case of the latter, however, crop rotation and especially clean culture during the winter will aid greatly in reducing the spring and summer broods by destroying the hibernating lice. In the localities where the grain is allowed to grow through the winter affording ideal feeding places for the over-wintering viviparous females, the aphid is worst, making control practically impossible.

THE CLOVER-APPLE APHIS

Aphis bakeri Cowen

Description.—The stem-mothers are pink or deep red with green markings on the dorsum arranged in a mottled effect. The honey-tubes are short and pale yellow. The size is medium, the length averaging about 1-12 inch. This form is usually found upon fruit trees early in the spring. The later generations are yellowish-green with an orange-colored spot at the base of each cornicle. The color of specimens feeding on clover varies from yellowish-green to pink. The winged forms are yellowish-green with the antennæ, head and thorax black. There is also a conspicuous shining black patch on the dorsum of the abdomen. The legs, honey-tubes and tail or cauda

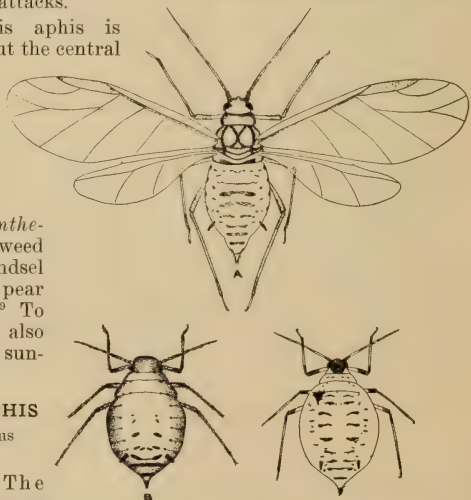
are dusky green. The honey-tubes are shorter than those of the green apple aphid.⁵⁸

Life History.—As in the case of many other aphids the eggs are laid upon fruit trees in the fall and hatch into the stem-mothers in the spring. These stem-mothers remain upon the fruit trees and bring forth a brood of young which also work for a time at least upon the foliage of the trees. As the winged migratory forms appear they leave the trees for clover and other plants, where they remain during the summer. In the fall, migrants return to the fruit trees and give birth to true sexual forms which mate and the females lay the over-wintering eggs. On certain plants in this State, such as the German ivy or groundsel,⁵⁹ the viviparous females may exist throughout the entire year. In many parts also it is doubtful if any eggs are laid at all, the mature viviparous females simply continuing through the winter in a more or less inactive condition.

Nature of Work.—On fruit trees there is a slight curling of the leaves in the spring, which is not nearly as serious as is caused by either the green or the rosy apple aphid. Clover and other plants show little or no effects of their attacks.

Distribution.—This aphid is distributed throughout the central and northern parts of the State.

Food Plants.—The following plants are hosts: alfalfa, *Am-sinckia*, apple, crab apple, globe artichoke, chamomile (*Anthemis*), clover, cudweed (*Gnaphalium*), groundsel (*Senecio*), hawthorn, pear and California sage.⁵⁹ To this list Davidson also adds the common sunflower.



THE CABBAGE APHIS

Aphis brassicae Linnaeus

(Fig. 70)

Description.—The adult is dark green or yellowish with narrow somewhat broken transverse brown lines across the abdomen of most of the winged and apterous females. The body is entirely covered with a fine white powder. This aphid collects in large, dense colonies on the food plants and is readily distinguished by the whitish covering.

Fig. 70.—The cabbage aphid, *Aphis brassicae* Linn. Winged and apterous females. Greatly enlarged. (Author's illustration. P. C. Jr. Ent.)

⁵⁸Wilson, H. F., *Bien. Crop Pest and Hort. Rept. Ore. Agrcl. Exp. Sta.*, p. 89, 1911-1912.

⁵⁹Davidson, W. M., *Jr. Ec. Ent.*, VII, p. 133, 1914.

Life History.—The cabbage aphid appears with the first plants in the spring and increases with such rapidity as to soon almost entirely cover the host. This condition prevails throughout the early summer, after which the parasites begin to reduce their numbers. During the winter also colonies may be found feeding upon various plants, without any interruptions, though in only limited numbers. Eggs are laid on old plants.

Distribution.—It is exceedingly common throughout the entire State.

Food Plants.—Practically all members of the family *Cruciferae* including broccoli, cabbage, cauliflower, *Isatis tinctoria*, kale, kohlrabi, mustard, radish, rutabaga, shepherd's purse, etc., are attacked.

Natural Enemies.—The ladybird beetles, *Hippodamia convergens*, *Megilla maculata fuscilabris* and *Coccinella californica*, prey to some extent upon this pest. The internal parasite, *Diaretus californicus* Baker⁶⁰ also attacks it. These enemies are not a factor in its control.

THE MELON APHIS

Aphis gossypii Glover

(*Aphis cucumeris* Forbes)

(Fig. 71)

Description.—The adult plant lice are small and very dark in color, varying from yellowish to dark green, brown or black. The apterous agamic female is usually dark green with often irregular lighter markings on the abdomen. The nymph is somewhat lighter than the apterous female.

Life History.—The over-wintering plant lice appear early in the spring, infesting all sorts of plants and often becoming a most serious pest before the farmer is aware of their presence. They continue to work until about the middle of the summer, when their numbers gradually decrease and only a few hibernate or feed during the winter.



Fig. 71.—The melon aphid, *Aphis gossypii* Glover. Winged and apterous females. Greatly enlarged. (Author's illustration, P. C. Jr. Ent.)

Distribution.—This species occurs throughout the entire State and this is one of the most common aphids.

Food Plants.—The foliage and young shoots of the plants are attacked. On citrus trees the tender shoots are often entirely destroyed.

⁶⁰Baker, C. F., P. C. Jr. Ent. I, p. 25, 1909.

Vines are injured throughout. The recorded food plants are: asparagus, begonia, buckthorn, catalpa, citron, cotton, cucumber, dock, dogwood, gourd, grapefruit, hop, hydrangea, iron-weed, jimson weed, lambsquarters, lemon, malva, morning glory, muskmelon, orange, pear, pepper grass, pigweed, plantain, shepherd's purse, spinach, sugar beet and watermelon.

Natural Enemies.—The ladybird beetles, *Hippodamia convergens*, Guer., *Coccinella californica* Mann., *Scymnus sordidus* Horn, *Cycloneda sanguinea* (Linn.) and many others, and the larvæ of the green lacewing, *Chrysopa californica* Coq. are predaceous, while the hymenopterous parasites *Aphidius testaceipes* (Cr.) and *Charips xanthopsis* (Ashm.) are parasitic upon this aphid in California. The last is probably secondary.

THE BUR CLOVER OR COWPEA APHIS

Aphis medicaginis Koch

(Fig. 72)

Description.—The mature females are of medium size and shiny black color. The immature forms are often reddish-brown. The abdomen of the winged form is usually dull-brown or greenish with dark transverse bands on the dorsum. Very noticeable characters of both apterous and winged lice are the yellow or whitish legs, which are dark only at the joints, and the light basal half of the antennæ. These markings, together with the short black honey tubes of the shiny black adults, usually serve to distinguish this form from all others. The length averages about 1-12 inch.

Life History.—The life history has not been worked out in this State, except to observe the summer forms. The eggs are laid in the fall on locust.

Nature of Work.—The lice collect in large colonies upon the stems and leaves of the host plants, causing them to become pale and sickly. The attacks usually do not continue long enough to cause serious damage.

Distribution.—This is a very common aphid throughout the entire State.

Food Plants.—The bur clover or cowpea aphid attacks alfalfa, apple, bean, *Caragana aborescens*, clover, cowpea, dandelion, dock, lambsquarters, wild liquorice, loco-weed, clammy locust, false-mallow, meadow-grass, *Melilotus italica*, mustard, orange, pear, pepper-grass, primrose, rhubarb, senna, shepherd's-purse, *Sophora* and tansy. There is some confusion regarding the identity of this louse, so that some of the plants listed may prove to be wrongly credited as hosts of this species.



Fig. 72.—The bur clover or cowpea aphid, *Aphis medicaginis* Koch. Greatly enlarged. (Author's illustration, P. C. Jr. Ent.)

THE OLEANDER OR MILKWEED APHIS

Aphis nerii Fonscolombe(*Aphis lutescens* Monell)

(Fig. 73)

Description.—The apterous form is deep yellow with dark antennæ and the cornicles, head and leg joints dusky. The winged form is also yellow with black spots on the thorax, a black blotch at the base of each cornicle and dark head, antennæ, cornicles and leg joints.

Life History.—In the spring the insects appear upon the tender shoots of the oleander, indicating that the over-wintering eggs were laid upon this plant in the fall. Later in the spring the lice migrate to the various species of milkweed where they remain throughout the summer or until the plants die in the fall. They then migrate to the oleanders where true sexual forms are born and the over-wintering eggs are laid.



Fig. 73.—The oleander or milkweed aphid, *Aphis nerii* Fonsc. Greatly enlarged. (Author's illustration, P. C. Jr. Ent.)

Distribution.—This louse occurs throughout the entire State.

Food Plants.—The buds and terminal shoots of the oleander and the various species of milkweed are attacked.

Natural Enemies.—The common ladybird beetles prey upon this species to some extent, the internal parasites, *Aphidius testaceipes* and *Charips xanthopsis*, and Syrphid flies, especially *Syrphus americanus*, also prey upon it. *Charips xanthopsis* is probably secondary.

THE BLACK PEACH APHIS

Aphis persicæ-niger Smith

(Fig. 74)

Description.—The full-grown winged and apterous forms are about $\frac{1}{8}$ inch long, robust and shiny black in color. The young are reddish-yellow or brownish and are always more abundant than the shiny black adults. The shining black color of the adults occurring on the peach make the determination of the species quick and certain. Like the woolly apple aphid, it has a root and an aerial form and is responsible for much damage, especially to young trees.

Life History.—The insect winters over on the roots of peach trees, where it may also be found in the summer. The first aphids appear above ground very early in the spring and begin attacking the tender leaflets, shoots or suckers, usually those at the base of the tree or nearest the ground. These first plant lice are all wingless. As soon as the buds, young fruit and leaves appear they are promptly attacked, the entire crop often being almost completely ruined. The leaves are curled and weakened, while the young fruit is so distorted as to be killed or rendered unfit for market. During the months of April and May winged migratory females appear, which start colonies upon other trees. The work continues until about the middle of July, when most of the lice leave the tops and again go to the roots.



Fig. 74.—Peach twig showing effects of an attack of the black peach aphid, *Aphis persica-niger* Smith. (Courtesy of Prof. C. W. Woodworth.)

Nature of Work.—This species works upon the young shoots, as well as the roots of the host plants.

Distribution.—This insect is at the present time found in nearly every peach-growing county in the State, and may be expected to appear in practically every such locality.

Food Plants.—The black peach aphid attacks the roots and foliage of the peach and wild plum and the roots of almond, plum and prune, when grafted on peach trees.

Natural Enemies.—Internal hymenopterous parasites, the larvæ of syrphid flies and the green lacewing prey very effectually upon this aphid.

THE GREEN APPLE APHIS

Aphis pomi De Geer

(*Aphis mali* Fabricius)

In order that the readers may get a true idea of the development and habits of plant lice the full life history of this species taken largely from the investigations of Professor C. P. Gillette is given as an example:

Eggs.—We shall begin with the small black shiny eggs which are found in great numbers on the smooth bark of the rapidly growing twigs or water sprouts of the apple tree. When these eggs were first deposited some time during the months of October, November, or as late as December, they were of a beautiful green color, but with age turned to a shiny metallic black. A careful examination in winter of the young twigs and water sprouts of an orchard, which was infested with this insect the previous summer, will often show great numbers of these eggs, in some cases completely covering the twigs.

The eggs themselves are very tiny, not nearly as large as a pin-head, and are elongated or oval in shape. Only a small percentage

of them hatch, and this accounts for the large number necessary to produce so many lice for the coming spring. In the Eastern States where the winters are very severe it is estimated that only one per cent hatch. In California, however, a much larger percentage is able to withstand our milder climate, and so the succeeding infestations are even more severe here than they are in colder climates.

Just before the apple buds show green the eggs begin to hatch. This, of course, depends entirely upon the weather, and an early spring will bring a much earlier hatch than will a cold, late spring.

Stem-Mothers.—The young which hatch from the eggs in the early spring give rise to all succeeding generations, and are known as stem-mothers when fully developed. The first born are darker green than any of the succeeding broods. In seeking food they work into the newly opening buds and upon the first tender leaves. Due to their small size they can scarcely be noticed except by very careful observation. In warm weather the young will develop in two or three weeks and become adult stem-mothers. The stem-mothers, which are always wingless, still appear dark green and have dark head, feet, tail and honey tubes.

Second Generation.—Each stem-mother has the power (which we call parthenogenesis) to give birth to living young without intercourse with a male, for no males appear at all until late in the fall. The young thus born alive constitute the second generation. They are light green in color, are all parthenogenetic viviparous, or agamic females, and though most of them are wingless, a very few winged individuals appear.

Third Generation.—The new broods of the second generation develop in a few weeks and in turn give birth to living young like themselves, but this generation is accompanied by a large number of winged females. The apterous and winged viviparous females of the succeeding generations are those most usually observed in the orchards and cause the greatest amount of damage. A brief description of each is as follows:

Wingless Viviparous Female.—This form is somewhat larger than the original stem-mother, and is lighter green in color, with a yellowish tinge. The cornicles (honey tubes), tail, part of the antennæ and the extreme tips of the feet are dark. They also give birth to winged and apterous viviparous females.

Winged Viviparous Female.—These are recognized at once by their wings, which are usually folded roof-like over the back. The general color is black and green (the head, thorax, cornicles and portions of the legs and antennæ being black and the remainder green). Like the apterous forms they have power to produce both winged and wingless viviparous females. A crowded condition or lack of food supply results in the production of a larger percentage of the winged forms.

The appearance of the winged individual is very significant in that this migratory form is the principal means of distribution and of the formation of new summer colonies.

Throughout the entire summer months brood upon brood, each in turn producing other broods, give rise to millions of this destructive

pest, and this accounts for the great and infinite numbers. It has been estimated that a single stem-mother will give rise to one billion insects during a single season. With the coming of cold weather, and after the first frost, there is a rapid diminution in numbers, and soon practically all of the winged individuals disappear. This is brought about, by the development of true sexual forms, male and female.

Sexual Forms.—The viviparous females of the late fall, instead of producing individuals of their own kind, give birth to true sexual forms, male and female, both of which are apterous.

Sexual Female.—The sexual egg-laying female is much smaller than the summer form, and varies from a rich green to a brownish or reddish color. The head, cornicles, feet and tips of antennæ are dark.

Sexual Male.—The males are very small, hardly half as large as the other lice. They are easily recognized by their frail and slender bodies, long legs and light yellow color. The head and tail are noticeably dark. They are much more active than are the sexual females, with which they associate and may be confused. These sexes mate and the females lay the eggs which give rise to the first stem-mothers in the spring already referred to.

Nature of Work.—This aphid infests principally the tender terminal shoots, causing the leaves to curl and turn yellow. The young fruit is also attacked and rendered knotty and unfit for market.

Distribution.—The green apple aphid is common throughout the entire State and often proves to be a serious pest in many parts.

Food Plants.—The food plants of the green apple aphid are not many. It is found on the apple, pear, hawthorn, loquat, quince and flowering crab. Of the apples, those which appear to be the favorites are the Missouri Pippin, Rome Beauty, Black Twig, Ben Davis and Greening, though it works just as effectively on many other varieties. The Northern Spy is fairly free from its attacks.

THE BEAN APHIS⁶¹

Aphis rumicis Linnæus

(Fig. 75)

Description.—The adult apterous and winged females vary in color from reddish-brown to almost black. The bodies are often covered with a fine, white powder which may give them a grayish or even whitish appearance. The young are light reddish-brown.

Life History.—The life history of this species is the same as that of the melon aphid.

Distribution.—This aphid occurs throughout the entire State, but is more abundant in the southern part.

Host Plants.—Beans (all varieties), dock, English ivy and lambs-quarters are attacked.

⁶¹In the first edition and previous works of the writer, this aphid has been listed as *Aphis hedera* Kalt. H. F. Wilson believes this species to be *A. viburni* Scop. Besides the above plants it also attacks nasturtium and snowball. The eggs are laid upon the latter.

Natural Enemies.—The bean aphid is heavily parasitized by braconids and preyed upon by the larvæ of *Scymnus sordidus* Horn.



Fig. 75.—The bean aphid, *Aphis rumicis* Linn. Winged and apterous females with enlarged antennæ of the same. Greatly enlarged. (Author's illustration, P. C. Jr. Ent.)

THE ROSY APPLE APHIS⁶²

Aphis sorbi Kaltendbach

(*Aphis pyri* Boyer)

(*Aphis malifoliae* Fitch)

(Figs. 76, 77)

Description.—This insect gets its common name from its rosy or purplish color, which readily distinguishes it from the green apple aphid. The head and thorax of the winged forms are dark. The bodies of all are slightly covered with white powder which often gives them a grayish cast. The eggs are oval and shiny black.



Fig. 76.—The rosy apple aphid, *Aphis sorbi* Kalt. Winged and apterous females on an apple leaf. Enlarged three times. (Original)

⁶²This is also sometimes called the purple apple aphid

Life History.—The life history of this species is very imperfectly known. The eggs, laid upon the trees the previous fall, hatch in the spring, about blossoming time (February and March), and the young lice at once begin to attack the young leaves and fruit. The work upon the leaves is similar to that of the green apple aphid, but causing them to curl more and to turn yellow. The work upon the fruit is even more destructive, causing deformity and non-maturity. In most of the apple-growing sections of the State the attacks of this aphid have been exceedingly severe. About June the species leaves the fruit trees and migrates to unknown host plants, and does not return until fall, in time to give birth to true sexual forms, the females of which produce the over-wintering eggs. As in the case of green apple aphid, many successive and overlapping broods occur each year.



Fig. 77.—Apples disfigured by the attacks of the rosy apple aphid when the fruit was young. These were picked at harvest time. Reduced one half. (Original)

Nature of Work.—The curling of the leaves on the terminal shoots and the stunting of the fruit, which is severely attacked, are characteristic of the work of this louse.

Distribution.—This species is widely distributed in practically every apple-growing section of the State.

Food Plants.—The rosy apple aphid attacks mainly the foliage and young fruit of the apple, but it also works upon the hawthorn, white thorn and mountain ash.

THE BLACK CHERRY APHIS

Myzus cerasi (Fabricius)

(*Aphis cerasi* Fabricius)

(Fig. 78)

Description.—The stem-mothers which hatch from the over-wintering eggs are first dark brown, but gradually change to shining black when fully matured. The bodies are somewhat pyriform, the antennæ half as long as the body and dusky brown. The legs are also dusky brown. The cornicles are one fourth as long as the body, cylindrical and black. Until about the middle of July all of the lice are wingless. At this time winged migrants begin to appear. The succeeding broods differ little from the first stem-mothers. The legs are pale with apical half of femora, tips of tibiæ and tarsi dark. The antennæ

are light with dark tips. The males which appear in the fall greatly resemble the females, but are much smaller, slender and have wings. The eggs are oval and black. This species is distinguished from the black peach aphid (*Aphis persicae-niger* Smith) by the long cylindrical honey tubes which usually point inwardly.



Fig. 78.—The black cherry aphid, *Myzus cerasi* (Fab.), on cherry leaf. Young and mature wingless females. Enlarged three times. (Original)

Life History.—The eggs are deposited during the fall in the crevices of the bark or upon the young twigs at the bases of the fruit spurs. They hatch in the spring about the first of March when the buds open and the young begin feeding at the base of the flowers and leaves or enter the opening buds and feed upon the latter. As the leaves appear they become infested by succeeding broods. The insects may be found upon the trees throughout the entire summer and often do considerable damage by curling and dwarfing the foliage. True sexual males and females appear in the fall, mate and the latter deposit the over-wintering eggs.

Nature of Work.—The plant lice collect in great numbers near the tips of the branches, small shoots and spurs, causing the leaves to curl and eventually drop. Much damage may be done where severe infestation occurs, especially in nurseries.

Distribution.—This aphid occurs quite commonly throughout the central and northern parts of the State.

Food Plant.—The cherry is the only recorded host.

THE GREEN PEACH APHIS

Rhopalosiphum persicae (Sulzer)[*Myzus persicae* (Sulzer)](*Aphis persicae* Sulzer)(*Rhopalosiphum dianthi* Schrank)(*Myzus achyranthes* Monell)

(Fig. 79)

Description.—The color of this species varies from yellowish to rich green. The winged form has a dark olive-green head, thorax and a prominent dark patch on the dorsum of the abdomen as shown in Fig. 79. The apterous form is pale green or yellow without dark markings. The adults are of medium size, varying from 1-16 to 1-12 inch in length.



Fig. 79.—The green peach aphid, *Rhopalosiphum persicae* (Sulz.). Winged and apterous females. Greatly enlarged. (Author's illustration, P. C. Jr. Ent.)

Life History.—The spring forms hatch from eggs deposited the previous fall, just when the new foliage begins to appear. All twigs, and especially the tender growths, are quickly attacked. Breeding continues throughout the entire spring and summer on any of the host plants. In the fall males and females appear, and, mating, give rise to the wintering eggs and the next year's broods. More commonly they feed upon weeds throughout the winter and do not go through the egg stage in California, as in colder climates.

Distribution.—This aphid occurs throughout the entire State.

Food Plants.—*Amsinckia spectabilis*, apricot, cabbage, carnation, cauliflower, celery, cherry, chrysanthemum, citron, cucumber, egg-plant, grapefruit, groundsel, hound's-tongue, English ivy, lemon, lettuce, false mallow, malva, mustard, nettle, orange, peach, pepper, pigweed, plum, Bullace-plum, potato, radish, rhubarb, shepherd's purse, snap dragon, sow-thistle, spinach, turnip, tomato and English walnut are among a large list of plants attacked by the green peach aphid.

THE SMALL GREEN ROSE APHIS

Myzus rosarum (Walker)⁶³(*Aphis rosarum* Walker)

(Fig. 80)

Description.—This louse is yellow or light green with dark markings on the adults as shown in Fig. 80, and only about half as large

⁶³W. M. Davidson also records *Rhopalosiphum nervatum* Gillette as quite injurious to roses at Walnut Creek, Contra Costa County. This species greatly resembles *Myzus rosarum* (Walker), but is somewhat larger and has conspicuous black nervures or veins in the wings.

as the large rose aphid, *Macrosiphum rosæ* Linn., for which it is often mistaken.

Life History.—It is a very serious rose pest at times, and especially bad in the summer months, breeding very rapidly and collecting in great numbers upon the leaves. It works throughout the summer and is the worst rose pest in many parts of the State.



Fig. 80.—The small green rose aphid, *Myzus rosarum* (Walk.). Winged and apterous females greatly enlarged. (Author's illustration, P. C. Jr. Ent.)

Nature of Work.—All stages attack the young buds, tender shoots and the old hardy foliage of the bushes, preventing a normal production of flowers, and secreting quantities of honey-dew which covers the bushes and furnishes a medium of growth for the black smut fungus.

Distribution.—This species occurs throughout the entire State.

Food Plants.—All varieties of roses are attacked.

Natural Enemies.—Syrphid flies do considerable work upon this species, but the natural enemies are not numerous enough to check the ravages until after most of the damage is done.

THE PARSNIP PLANT LOUSE

Siphocoryne capreæ Fabricius⁶⁴

[*Hyadaphis capreæ* (Fabricius)]

(*Rhopalosiphum capreæ* Fabricius)

(Fig. 81)

Description.—The apterous females are pale green and sometimes have a few small red spots on the dorsum. The winged forms are green with the head, antennæ, thorax, middle dorsum of the abdomen, tips of the cornicles and the leg joints dark or black. This species may be distinguished from a closely related species, *Siphocoryne pastinacæ* (Linn.), by the presence of a small tubercle just above the cauda or tail. This tubercle is entirely absent in the latter.

⁶⁴There is some difference of opinion regarding the position of this species. Prof. C. P. Gillette places it in the genus *Rhopalosiphum* (Jr. Ec. Ent., IV, p. 320, 1911), while J. J. Davis puts it in the genus *Hyadaphis* (Jr. Ec. Ent., III, pp. 493-494, 1910). H. F. Wilson considers the genus *Siphocoryne* correct. All previous references to *Hyadaphis pastinacæ* (Linn.) by the writer should have been to this species instead.

Distribution.—This plant louse is widely distributed throughout the State.

Food Plants.—The parsnip plant louse like its close relative, *S. pastinacæ* (Linn.), attacks only plants belonging to the *Umbelliferae*

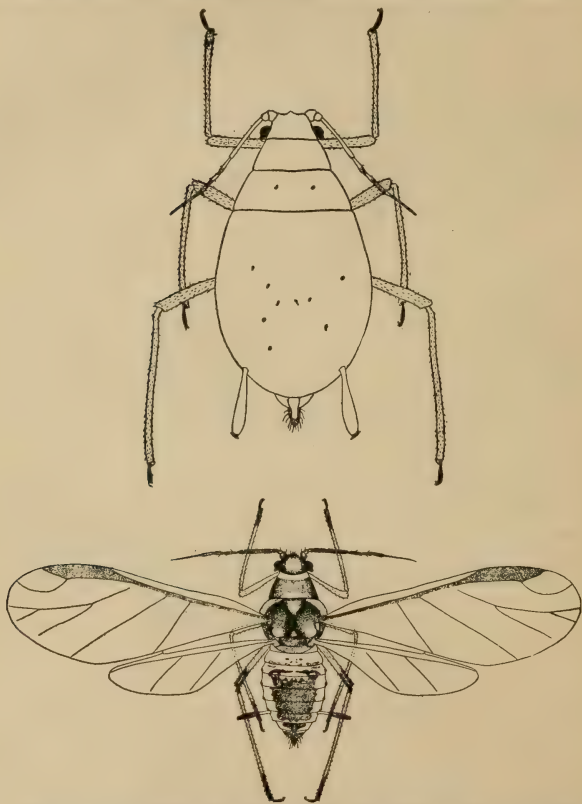


Fig. 81.—The parsnip plant louse, *Siphocoryne caprea* (Fab.) Apterous and winged viviparous females. Greatly enlarged. (Author's illustration, P. C. Jr. Ent.)

and the willows, including *Angelica sylvestris*, *A. atropurpurea*, caraway, carrot, celery, *Charophyllum temulum*, goutweed, water hemlock, *Ligusticum porteri*, treacle mustard, parsley, parsnip, cow-parsnip, *Pimpinella magna*, willow (many species) and *Zizia aurea*.

The sexual females lay the over-wintering eggs on the willow, upon which the spring broods feed. Winged forms migrate later to other plants, where the summer is passed, and still others migrate again to the willow in the fall, to give birth to sexual forms, which lay the winter eggs.

THE BROWN VIOLET APHIS

Rhopalosiphum violæ Pergande

Description.—All stages are dark red or brown and the wings are noticeably clouded along the veins, which easily distinguishes this species from all others infesting violets.

Life History.—The viviparous winged and apterous females bring forth young continually throughout the early spring and the summer months. Little is known regarding the egg-laying habits. In the southern part of the State it is found the year round upon the violet. The louse works upon the tender shoots and undersides of the older leaves causing distortions.

Distribution.—This species has been reported only from the southern and central parts of the State.

Food Plant.—Cultivated violets are attacked by this pest.

THE BLACK FERN PLANT LOUSE⁶⁵*Idiopterus nephrolepidis* Davis*(Macrosiphum kirkaldyi* Fullaway)

(Fig. 82)

Description.—The mature winged and apterous viviparous females are dark green or jet-black in color with light markings on the antennæ, legs and honey tubes. The wings are beautifully clouded, as shown in Fig. 82. The average length is about 1-16 inch.



Fig. 82.—The black fern plant louse, *Idiopterus nephrolepidis* Davis. Apterous and winged females. Greatly enlarged. (Author's illustration, P. C. Jr. Ent.)

Distribution.—This plant louse is quite generally distributed throughout the State and is usually to be found in greenhouses and ornamental gardens.

Food Plants.—The Boston fern is a preferred food plant though it has also been taken on golden fern (*Acrostichum reticulatum*) and sword fern.

⁶⁵P. C. Jr. Ent. III, pp. 538-541, 1911.

THE HOP APHIS

Phorodon humuli (Schrank)*(Aphis humuli Schrank)*

Description.—The wingless viviparous female is pale yellowish-green and the winged form is the same general color with the head, dorsum of the mesothorax and spots on the abdomen dark.

Life History.—The life history of this louse greatly resembles that of the mealy plum plant louse. The over-wintering eggs are laid upon the plum trees in the fall. The spring broods feed upon the leaves and give birth to new broods until the hops begin to appear. By this time winged migrants appear in large numbers and these migrate to the hop fields where they live during the summer. The young plants and foliage of the hop vines are severely damaged by this pest, which may completely ruin portions of the crop. In the fall, migrants return to the plum trees, and give birth to the sexual forms which produce the over-wintering eggs. The sexual forms occur also in the hop fields, while the different stages may be found upon the plum trees during the summer, so in all probability they can exist upon either of these hosts throughout the season.

Distribution.—This species is very common and destructive, especially in the central hop-growing districts of the State.

Food Plants.—This is primarily a hop pest and is certainly one of the worst enemies of that crop. It also feeds upon plum trees, occurring upon either hops or plums throughout the summer.

THE LUPINE APHIS⁶⁶*Macrosiphum albifrons* Essig

(Fig. 83)

Description.—This is a large green louse, completely covered with fine white powder or pulverulence, which makes it appear silvery-gray. The length varies from $\frac{1}{8}$ to $\frac{1}{6}$ inch.

Life History.—The lice appear in the spring, soon after the lupines are well started and are especially abundant about flowering time. The younger shoots and especially the flowering tips are attacked, and many lice continue to work upon the green seed-pods. The species collects in large colonies and works great havoc to the hosts.

Distribution.—This species occurs in many parts of the State.

Food Plant.—The lice attack the wild lupine (*Lupinus albifrons*).

Natural Enemies.—The writer has reared a large undetermined internal parasite from this aphid.

⁶⁶W. M. Davidson reports a species very much like this, if not the same, attacking vegetables and lupines in the San Francisco Bay Region.



Fig. 83.—The lupine aphid, *Macrosiphum albifrons* Essig, on stem and pod of lupine. Enlarged three times. (Author's illustration, P. C. Jr. Ent.)

THE GREEN CITRUS PLANT LOUSE

Macrosiphum citrifolii (Ashmead)

(*Siphonophora citrifolii* Ashmead)

(Fig. 84)

Description.—This is a large green plant louse, about the size of and greatly resembling the destructive pea aphid in color and shape. Under the microscope it will be found that the tips of the cornicles (honey-tubes) of the pea louse are perfectly plain, while there are mosaic markings or reticulations on those of the green citrus louse.

Life History.—The young insects appear on the tender shoots early in April and are especially abundant on young orange trees in the nursery. Winged and apterous viviparous females continue to appear throughout the entire summer, but only in the spring and early summer is this species a pest.



Fig. 84.—The green citrus plant louse, *Macrosiphum citrifolii* (Ashm.). Apterous and winged females. Greatly enlarged. (Author's illustration, P. C. Jr. Ent.)

Distribution.—It occurs throughout the citrus belt of southern California.

Food Plants.—The green citrus plant louse occurs especially abundant on young orange seedlings and on suckers of large seedling orange trees. It is probable that the older foliage of most of the orange trees is also attacked.

Natural Enemies.—The larvæ of the predaceous ladybird beetle (*Hippodamia convergens*) feed upon this insect in limited numbers. The most efficient predators, however, are the larvæ of the green lacewing (*Chrysopa californica*) and the large syrphid fly (*Syrphus pyrastris*). The internal parasite *Charips xanthopsis* also preys upon it. The internal parasite, however, is probably only secondary.

THE DESTRUCTIVE PEA APHIS

Macrosiphum pisi (Kaltenbach)

[*Macrosiphum destructor* (Johnson)]

(*Nectarophora pisi* Kaltenbach)

(Fig. 85)

Description.—The adult is a large, pea-green aphid, easily distinguished by the long legs and antennæ. The head and thorax of the winged forms are pinkish or yellow while there are no markings on the apterous female.

Life History.—This species feeds practically throughout the year on perennial legumes like alfalfa and clover as well as the annuals used for cover crops during the winter and upon the annuals as peas, etc., during the summer months. They are exceedingly prolific and often very destructive, especially to crops of peas. The winter is either passed as immature or adult viviparous females as indicated above or as eggs deposited on the perennial hosts.

Distribution.—The destructive pea aphid occurs throughout the entire State.

Food Plants.—Alfalfa, clover, fenugreek, garden and field pea, vetch and other legumes are attacked.



Fig. 85.—The destructive pea aphid, *Macrosiphum pisi* (Kalt.). All stages of apterous and winged females. Enlarged three times. (Original)

THE LARGE ROSE APHIS

Macrosiphum rosæ (Linnaeus)

(*Aphis rosæ* Linnaeus)

(Fig. 86)

Description.—This is a large aphid represented by two distinct color varieties, the body of one bright green and of the other, pinkish. The apterous forms have dark cornicles and dusky antennæ and leg-joints. In the winged forms the thorax and antennæ are also dark and there is a row of dark spots on either side of the abdomen. The length varies from 1-12 to 1-8 inch. This species is readily distinguished from the other rose aphids by the large size, black cornicles and the presence of the pink forms.

Life History.—In California this species does not appear to lay eggs, but to live upon the rose bushes throughout the year. It is specially abundant during the early spring and early fall, being less numerous in midsummer and midwinter. It attacks the young buds and tender shoots and may greatly retard blooming or prevent the development of perfect flowers.

Distribution.—This species occurs throughout the State.

Food Plants.—Wild and cultivated roses are attacked.

Natural Enemies.—Natural enemies prey extensively on this pest. The internal parasite, *Lysiphlebus abutilonaphidis* Ashm.⁶⁷ has been reared from it in California.

⁶⁷Insect life, III, 61, 1890.



Fig. 86.—The large rose aphid, *Macrosiphum rosa* (Linn.). Winged and apterous females. Greatly enlarged. (Author's illustration, P. C. Jr. Ent.)

THE RED COMPOSITE APHIS

Macrosiphum rudbeckiæ (Fitch)

(*Aphis rudbeckiæ* Fitch)

(Fig. 87)

Description.—The aphid is dark red in all stages, though the mature forms are often much darker than the young lice. It is large and conspicuous with relatively long antennæ and honey tubes. The color, size, habit of collecting in dense colonies and its very restless nature when disturbed make its identity easy. The length varies from $\frac{1}{16}$ to $\frac{1}{8}$ inch.



Fig. 87.—The red composite aphid, *Macrosiphum rudbeckiæ* (Fitch). Greatly enlarged. (Author's illustration, P. C. Jr. Ent.)

Distribution.—This plant louse is found throughout the State.

Food Plants.—Many of the composite plants are attacked by this insect and it may usually be found on any of the following: aster, chrys-

anthemum, goldenrod, groundsel tree (*Baccharis* spp.), ragweed, *Rudbeckia* spp., rosin weed and thistle (*Cirsium*). To this list W. M. Davidson also adds the fuller's teasel.

COCCIDÆ (Family)

SCALE INSECTS

To the California horticulturist, and especially to the citrus fruit grower, the scale insects are known to be by far the most destructive, persistent and expensive pests. More money is spent combatting three or four of them than for all other insects combined. To the nurserymen and florists, too, these insects are ever present annoyances and the cause of much trouble. Nearly every plant is attacked and species considered of no economic importance may eventually become pests to cultivated crops. It is no wonder, then, that so much space is given for the consideration of these insects, and so many apparently non-economic species are included in this work.

The majority of the members of the family *Coccidæ* have the ability to produce a scale-like covering from which the common name is derived, while some, unable to form a scale, have the epidermis hardened into a thick, hard, chitinous wall, and still others secrete an abundance of white powdery or cotton-like wax as a covering. The scale, thickened epidermis and waxy covering are apparently for the protection of the adults, eggs and young and prove so to a large measure, and also enable the scale insects to resist to a marked degree spraying and fumigation.

The young are either born alive or hatch from eggs previously laid by the female. In the first case the young hatch within the body of the female from what corresponds to the egg, and in the latter case the eggs are laid and hatch outside the body, in a shell or in a cottony mass or sac secreted by the female for this purpose. The young always have six legs, enabling them to move about freely. In many genera the legs are retained throughout the entire life cycle, allowing the adults to move as freely as the young, but in the scale-bearing forms, and many others, the legs disappear in the females after the first moult, there being nothing but the small body under the scale, held in place by the proboscis and scale.

The males at first resemble the young females, but soon after birth make a tiny scale or cocoon in which transformation takes place, the adults after the last moult emerging as very small, delicate, two-winged insects with antennæ and six legs, when the females are about one third or full-grown. At this period mating takes place and the males soon die.

Nature of Work.—Scale insects feed by inserting into the tissues of the plants (bark, fruit and leaves) their small beaks or mouth-parts and sucking out the juices. As a consequence of their great numbers and the removal of a large amount of juices, or a toxic effect produced by the scales, the plants are often so weakened as to mature little or no crops, or they may be entirely killed, while the fruits may be deformed or rendered unsightly, and therefore unfit for market.

Control.—The control of scale insects has long been one of great importance throughout the entire country. Formerly only sprays

were used in combatting them, but during the past few years fumigation, especially in the citrus growing sections of the State, has become the principal control method. Scale insects occurring on deciduous fruit trees are most efficiently and cheaply controlled by the use of sprays, and the mealy bugs on citrus and other trees are also usually subjected to a similar treatment. All armored scales (red scale, yellow scale, purple scale, etc.), as well as such unarmored scales as the black scale and soft brown scale on citrus trees, are most effectively controlled by fumigation.

Natural Enemies.—One of the most noted examples of the control of a serious insect pest by natural enemies is that of the cottony cushion scale (*Icerya purchasi*) by the Vedalia (*Novius cardinalis*). Other ladybird beetles and internal parasites also form an important part in the control of scale insects, being apparently responsible for the subjection of many non-economic species. Other insects, also, prey upon coccids, as will be noted in the discussion of the various species.

Subfamilies.—In this work only five of the many subfamilies will be considered, as these embrace all of the common species known in California. They are:

Monophlebina

Ortheziina

Dactylopiina

Coccina

Diaspina

MONOPHLEBINÆ (Subfamily)

The females belonging to this subfamily are characterized by secreting, behind the soft and unprotected bodies, a large white cottony egg-sac. The bodies of the young scales are almost entirely without protective covering, while those of the adult females are usually covered with a waxy secretion. The males are delicate, two-winged insects. In California we have but one species, the cottony cushion or fluted scale (*Icerya purchasi*), which is of economic importance.

THE COTTONY CUSHION OR FLUTED SCALE

Icerya purchasi Maskell⁶⁸

(Fig. 88)

Description.—The fully-matured females are easily distinguished by the large, white, fluted, cottony egg masses at the posterior end of the red, yellow or dark brown bodies—which together are from $\frac{1}{4}$ to $\frac{1}{2}$ inch long and three fourths as wide. The eggs are deposited within the cottony mass and are oblong and rich cardinal-red. From four hundred to a thousand may be laid by a single female. The young are bright red with dusky legs and antennæ and several long tail-

⁶⁸Two varieties of *Icerya purchasi* have been named by Dr. T. D. A. Cockerell as follows: *crawii* in which the body proper is yellow or light brown and *maskelli* in which the body is dark brown or almost black. The two varieties are undoubtedly a single species with slight differences in color which vary from yellow to almost black with all shades between.

like hairs at the posterior end. The males are small two-winged red-bodied insects with long antennæ and white anal appendages.

Life History.—The large cottony masses are the egg-sacs of the females, and may contain from four hundred to a thousand eggs. The males soon after hatching secrete themselves in a white cocoon for transformation, which requires nearly one month. The females are matured in from three to four months. There are several broods during the summer, when the scale increases enormously, and may even yet occasionally do great damage.



Fig. 88.—The cottony cushion or fluted scale, *Icerya purchasi* Mask., on Australian blackwood. Natural size. (Original)

Nature of Work.—This scale reproduces so rapidly that unless checked all of the branches and foliage often become so thickly infested that the tree or plant may be greatly weakened or completely killed.

Distribution.—The cottony cushion scale is well known throughout the citrus growing sections of the entire State, but due to its natural

enemies is only occasionally seen in some localities. However, in others it may become serious for brief periods or until the natural enemies find it.

Food Plants.—Acacia, alfalfa, flowering almond, apple, apricot, castor bean, Australian blackwood, boxwood, cedar of Lebanon, chrysanthemum, citron, cypress, fig, geranium, goldenrod, grape, grapefruit, Bermuda grass, sweet gum, hackberry, iron-weed, knotweed, lambsquarters, laurel, lemon, locust, magnolia, nettle, nightshade, holly oak, laurel oak, white oak, orange, trifoliate orange, peach, pear, pecan, pepper, pigweed, pine, *Pittosporum*, poinsettia, pomegranate, potato, purslane, quince, ragweed, rose, spearmint, sunflower, verbena, English walnut and willow are attacked by the cottony cushion scale.

Control.—Artificial control by sprays and fumigation is not usually practiced, because of the efficiency of natural enemies. This is the one case where nature nearly always controls perfectly a serious pest.

Natural Enemies.—For convenience the natural enemies of this scale are classed under two headings as predaceous, or those actually devouring the host, and as parasitic, or those feeding on and living within the body of the host.

Predaceous Enemies.—The common vedalia (*Novius cardinalis*) and the Koebele's ladybird beetle (*N. kœbelei*) are most responsible for keeping the cottony cushion scale in complete subjection. In many localities the former is the most efficient, but in some places, and especially in Ventura County, the writer found the latter doing more of the control work.

While these ladybirds are usually present in limited numbers in most sections, yet at times they completely disappear and the cottony cushion scale increases so as to cause considerable damage before the beetles can be re-established. It is always well to keep a close watch of the pest, and if it appears without being accompanied by the larvae of the ladybird beetles, adults should be obtained and liberated as soon as possible.

Parasitic Enemies.—There are several internal hymenopterous parasites of this scale, including *Ophelosia crawfordi*, *Thoron opacus* How., *Coccophagus californicus* How. and *Encyrtus dubius* How.⁶⁹ The dipterous parasite, *Cryptochatum* (*Lestophonus*) *iceryæ* Will., is very common in the southern part of the State, and often does remarkable work. In the year 1913 Mr. A. S. Hoyt reported a splendid cleanup of the scale in Los Angeles County by this parasite.

⁶⁹Insect Life, I, p. 270, 1889.

ORTHEZIINÆ (Subfamily)

The members of this subfamily are soft-bodied insects, without special protection. The females are characterized by their long legs and long white egg-sacs at the posterior end of the body, as shown in Fig. 89. The bodies are also slightly covered with a white wax. Throughout the entire life cycle the females are very active. But one species, *Orthezia insignis*, is of economic importance in California.



Fig. 89.—The sage Orthezia, *Orthezia artemisiae* Ckll. Mature females with well developed egg-sacs. (Author's illustration, P. C. Jr. Ent.)

THE GREENHOUSE ORTHEZIA

Orthezia insignis Douglas⁷⁰

(Fig. 90)

Description.—The bodies of the females are ochreous or dark green with a marginal fringe of white waxy plates, which are extended posteriorly in a large rectangular projection which serves as an egg-sac. The dorsum of the bodies is bare with the exception of a median waxy longitudinal ridge. The bodies with the egg-sac measure about $\frac{1}{4}$ inch. The young females have the marginal fringe and the dorsal median longitudinal ridge of white wax, but lack the long white egg-sac of the mature females. The males are exceedingly small, dark green in color, with two wings and two long white posterior waxy filaments.

Life History.—There are several generations a year. The young females vary from yellow to green in color, and as they grow the white wax forms like a fringe around the edges as a distinct middle longitudinal ridge, and the egg-sac begins to form. All stages are active.

Nature of Work.—The young and adults settle in colonies upon the leaves and stems and their constant sucking of the juices causes the

⁷⁰A much larger native species, *Orthezia artemisiae* Ckll., is common throughout the southern part of the State on the California sage (*Artemisia californica*). Fig. 89 shows this coccid very well.

plants to weaken, become sickly in appearance, and may even kill them completely.

Distribution.—This species is widely distributed throughout the State, in greenhouses, gardens and parks.



Fig. 90.—The greenhouse *Orthezia*, *Orthezia insignis* Dougl. Young and mature females on *Bignonia*. Slightly enlarged. Taken at Ventura by S. H. Essig. (Original)

Food Plants.—The scale is especially troublesome upon greenhouse plants, but often attacks garden and orchard crops, though it has never proven a serious outdoor pest in California. The following hosts are recorded: *Ageratum*, *Bignonia*, chrysanthemum, citron, coleus, *Cuphea*, *Gardenia*, grapefruit, iron-weed, *Lantana*, lemon, moonflower, orange, pepper, pigweed, sage, strawberry, *Strobilanthes*, tea, *Thunbergia*, tomato, verbena and yarrow.

Control.—As many delicate plants are attacked by this coccid, control measures are somewhat difficult. Daily syringing the plants so that all parts are thoroughly washed will remove many of the young before they are firmly attached to the leaves. Dipping the plants frequently in a solution of tobacco extract will also kill the young. If the infestation is confined to a very small area the complete destruction of the infested plants would completely eliminate a general infestation and might be a profitable step.

DACTYLOPIINÆ (Subfamily)

The members of this subfamily are much more varied than those of the two preceding. In some species the power of locomotion is retained throughout the entire life cycle, while in others the legs disappear after the first moult and the insects soon become fixed in position. The bodies are entirely unprotected except by the secretion of a white cottony powder or wax. The eggs may be enclosed in the secretion covering the females, or they may be deposited in cottony masses. Among the members are the mealy bugs, which are very troublesome in this State.

THE PIT-MAKING OAK SCALE

Asterolecanium variolosum Ratzeburg

(Fig. 91)

Description.—The scales are circular, shiny green or yellow, appearing semi-transparent and $\frac{1}{12}$ inch in diameter. It is a very pretty species, which is not often met with.

Distribution.—Though rather common in the Eastern States, it has been reported on a single oak tree on the high school grounds at Stockton, by Wm. Garden, and quite plentiful at Stanford University, by Professor R. W. Doane.

Food Plants.—Various species of oaks are attacked, including *Quercus sessiliflora*, *Q. glandulifera*, holly oak (*Q. ilex*) and *Q. aurea*. It sometimes kills the small twigs.

Control.—Control measures are the same as for soft brown scale or the European fruit Lecanium.



Fig. 91.—The pit-making oak scale, *Asterolecanium variolosum* Ratz. The twig on the right shows the pits made by the scale. Enlarged three times. (Original)

THE OAK CEROCOCCUS⁷¹

Cerococcus quercus Comstock

(Fig. 92)

Description.—The female scales are enclosed in a smooth or rough mass of rich yellow wax, well illustrated by Fig. 92. The individual

⁷¹Ehrhorn's *Cerococcus* (*Cerococcus ehrhorni* Ckll.) is common in the central part of the State on oak trees. It is a very small insect and is usually hidden under the scales of the bark and not at all conspicuous as the oak *Cerococcus*.

masses are somewhat globular in shape, averaging from $\frac{1}{8}$ to $\frac{1}{4}$ inch in diameter and nearly the same in height, though many are quite flattened. There are no distinct markings, but often a transverse median depression is slightly lighter in color.

Distribution.—The distribution of this pest is limited to the mountainous districts of the southern part of the State.

Food Plants.—Various species of oak trees are attacked, including the coast live oak. (*Quercus agrifolia*), *Q. oblongifolia* and *Q. undulata wrightii*.

BRANIGAN'S KERMES

Kermes branigani King

(Fig. 93)

Description.—The fully-developed females are nearly globular, being about $\frac{3}{16}$ inch long and $\frac{1}{4}$ inch wide. The color varies from light cream to yellow with four rather wide brown transverse bands. The segmentation is quite distinct, each suture being marked by numerous small black spots. The surface is shiny and thickly covered with very fine black specks, which are difficult to see without the aid of a hand lens.



Fig. 93.—Branigan's Kermes, *Kermes branigani* King, on maul oak. Enlarged twice. (After King. Photo by author. P. C. Jr. Ent. and Zool.)



Fig. 92.—The oak Cerococcus, *Cerococcus quercus* Comst., on coast live oak. Enlarged twice. (Original)

The species closely resembles *Kermes essigii* King, but is never gibbose.

Distribution.—So far this species has been taken at Forest Hill, Placer County, and near Redding, Shasta County, the latter having been but recently collected by Mr. Leroy Childs.

Food Plant.—The smaller branches, especially those in the shady portions of the tree, of the maul oak (*Quercus chrysolepis*) are attacked.

COCKERELL'S KERMES

Kermes cockerelli Ehrhorn

(Fig. 94b)

Description.—The mature females vary from light yellow to rich reddish-brown in color. They are nearly globular and decidedly gibbose, there being three transverse and one longitudinal sutures traversing the dorsum. The surface is shiny and lacks the minute black specks found in a number of species. The diameter averages about $\frac{3}{16}$ inch. The young and half-grown females are beautifully light red marked with bright yellow. They are not gibbose until nearly mature.

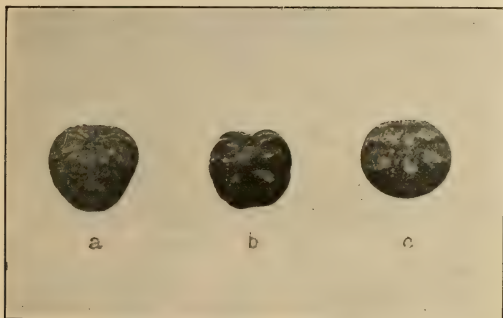


Fig. 94.—a, the western Kermes, *Kermes occidentalis* King; b, Cockerell's Kermes, *Kermes cockerelli* Ehrh.; c, the gall-like Kermes, *Kermes galliformis* Riley. Enlarged three times. (After King. Photo by author. P. C. Jr. Ent. and Zool.)

Distribution.—This is the most common of the California species and is very abundant in the central and northern parts of the State.

Food Plants.—The range of oaks upon which this species feeds is quite wide and includes the valley oak, maul oak and black oak, and probably others.

ESSIG'S KERMES

Kermes essigii King

(Fig. 95)

Description.—The full-grown females are nearly globular or slightly elongated, yellow to light brown, with cream-colored cross bands. Some specimens are quite dark and many are gibbose. The surface is shiny and peppered with many very minute and a few quite large black dots. The illustration (Fig. 95) gives a good idea of the shape and markings. The average width is about $\frac{3}{16}$ inch, the length about $\frac{1}{4}$ inch. The young females are dark reddish-brown and elongate or oval. This species is closely related to *Kermes nigropunctatus* and *K. galliformis*, but is larger than the former and the gibbose body separates it from the latter.

Distribution.—The species was first collected in the Santa Paula Canyon, Ventura County, by Fred Essig and later by the writer. S. A. Pease took it the next year at Ontario, San Bernardino County,

and R. S. Woglum at Pasadena, Los Angeles County. It is probably widely distributed in the southern part of the State.

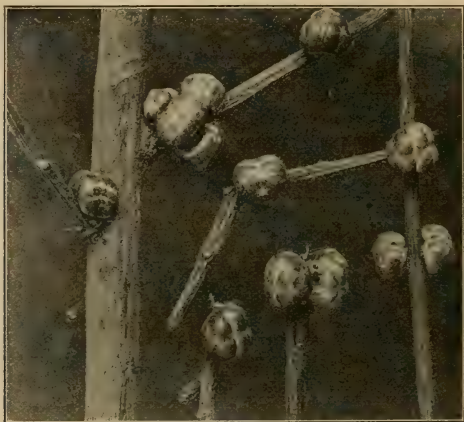


Fig. 95.—Essig's Kermes, *Kermes essigii* King. Adult females on twigs of the coast live oak. Enlarged twice. (After King. Photo by author. P. C. Jr. Ent. and Zool.)

Food Plant.—It is taken only upon the smaller branches of the coast live oak (*Quercus agrifolia*).

Natural Enemies.—Great numbers of several undetermined species of hymenopterous parasites were bred from this species by the writer.

THE GALL-LIKE KERMES

Kermes galliformis Riley

(Figs. 94c, 96)

Description.—The adult females are nearly spheroidal in shape, being slightly wider than long. The color is light brown with three quite wide, white or grayish cross bands and a median longitudinal band of the same color. There is also a general marbled effect in the mixing of the gray and brown, as shown in Fig. 96. The length is $\frac{3}{16}$ inch and the width $\frac{1}{4}$ inch. The surface is dull and covered with very minute black spots. The young



Fig. 96.—The gall-like Kermes, *Kermes galliformis* Riley, on black oak. Natural size. Collected in Yolo County by E. J. Branigan. (Original)

females are dirty-gray, elongate-oval in shape, and have six-jointed antennæ, two long anal hairs and three stout anal spines.

Distribution.—This species is common throughout the central part of the State, but also occurs in the southern part,⁷² and is quite widely distributed throughout the United States.

Food Plants.—The black oak (*Quercus kelloggii*) is the preferred host plant in California, but several other species of oak, including *Quercus emoryi*,⁷³ are reported in other states.

THE BLACK-PUNCTURED KERMES

Kermes nigropunctatus Ehrhorn & Cockerell

(Fig. 97)

Description.—The mature females are pale yellow, nearly globular and decidedly gibbose. There are three prominent transverse and one well defined median longitudinal sutures, all of which are usually paler than the rest of the body. The length averages $\frac{1}{8}$ inch, the width $\frac{1}{8}$ inch, and the height $\frac{1}{8}$ inch. The young females are pink, oval and one third as wide as long. This species is very near to *K. essigii* King, but appears to be smaller and usually much more gibbose.

Distribution.—The black-punctured kermes has been recorded only from Los Angeles County, but probably occurs in other localities of southern California.

Food Plant.—The coast live oak (*Quercus agrifolia*) is the native and only recorded food plant.



Fig. 97.—The black-punctured Kermes, *Kermes nigropunctatus* Ehrh. & Ckll., on coast live oak. Natural size. Collected in Los Angeles County by Leroy Childs. (Original)

THE WESTERN KERMES

Kermes occidentalis King

(Fig. 94a)

Description.—The fully-matured females are nearly globular in outline and gray in color. On the dorsum there are five transverse narrow blackish bands, which are broken at intervals by large black spots. The areas between the bands are light brown. The surface is dull and covered with very minute black specks. The diameter is about $\frac{3}{8}$ inch.

Distribution.—This scale was first taken in California by Mr. E. M. Ehrhorn, but the exact location was not given.

Food Plant.—It feeds on the limbs of oak (*Quercus* sp.).

⁷²*Kermes austini* Ehrh., reported from Escondido, San Diego County, is now considered by Mr. Geo. B. King as a synonym of *K. galliformis*.

⁷³King, Geo. B.: Psyche, IX, p. 79, July, 1900.

SASSCER'S KERMES

Kermes sassceri King

(Fig. 98)

Description.—The fully developed females are slightly longer than wide and vary from nearly white to light yellow. There is a prominent transverse median line which is dark brown and black and crossed with broken, transverse bands of the same color. There are also a few black spots as large as a pin head and many minute black specks on the surface, all of which make some specimens appear quite dark. The young females are grayish-brown.

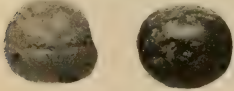


Fig. 98.—Sasscer's Kermes, *Kermes sassceri* King. Enlarged three times. (After King. Photo by author. P. C. Jr. Ent. and Zool.)

Distribution.—Though present in California, the exact locations are not given. It also occurs in the Eastern States.

Food Plants.—The red oak, *Quercus rubra*, is attacked in the East. The species of oak in California is not recorded.

THE COTTONY KERMES

Kermes shastensis Ehrhorn

(Fig. 99)

Description.—The female bodies are very nearly globular and rich mahogany-brown with three rather distinct dark-brown transverse lines across the surface, which is smooth and shiny. They are entirely enclosed in a rather thick white felt-like covering which gives them the appearance of round balls of cotton on the twigs. The diameter averages about $\frac{1}{4}$ inch. The white waxy covering is from $\frac{1}{32}$ to $\frac{1}{16}$ inch thick. In the young the antennæ are six-jointed and the legs short with the femora almost as broad as long. The immature females are light yellow.

Distribution.—This species occurs in the northern part of the State, having been collected at Shasta Springs.

Food Plant.—The Maul oak (*Quercus chrysolepis*) is the only recorded food plant of this species.

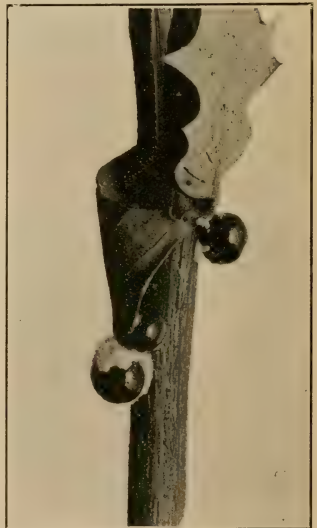


Fig. 99.—The cottony Kermes, *Kermes shastensis* Ehrhorn, on oak. The cottony covering has been partially or entirely removed. Slightly enlarged. (Original)

THE EUROPEAN ELM SCALE

Gossyparia ulmi (Linnæus)[*Gossyparia spuria* (Modeer)](*Coccus ulmi* Linnæus)

(Figs. 100, 101)

Description.—The adult females are readily distinguished by the white cottony fringes around the reddish-brown bodies (Fig. 101). They are from $\frac{1}{4}$ to nearly $\frac{3}{8}$ inch long and are usually clustered in the cracks and crevices in great numbers and from a distance appear as white rings. The males are very delicate, reddish, two-winged insects, with two long white anal filaments. The cocoons are white and less than $\frac{1}{12}$ inch long (Fig. 100).

Life History.⁷⁴—The eggs are oblong in shape, pale yellow, and hatch so quickly that many have thought that the young were born alive. The young appear during the early summer months and settle upon the leaves and smaller twigs until August and September, when they become nearly full-grown. They then move to the twigs and branches for hibernation. The males begin to issue in early spring. The females reach maturity and begin to bring forth the summer brood in May and June. There is but one brood a year.

Nature of Work.—This scale is very prolific and masses in great numbers upon the limbs of the elms. Besides the large amounts of honey-dew supporting the smut fungus, which render the trees very unsightly, the attacks greatly lessen their vitality.

Distribution.—The distribution of the European elm scale is quite definite and apparently confined to the following localities: San Rafael (Marin County), Ukiah (Mendocino County), Colusa (Colusa County), Palo Alto, Santa Clara, San Jose and Stanford University (Santa Clara County), Modesto (Stanislaus County) and Stockton (San Joaquin County).

Food Plants.—The following species of elm trees are attacked by this scale: American elm, cork elm, English elm, slippery elm and Wych or Scotch elm.

Control.—Washing the insects from the trees with an extension nozzle under high pressure during the period of hatching will control

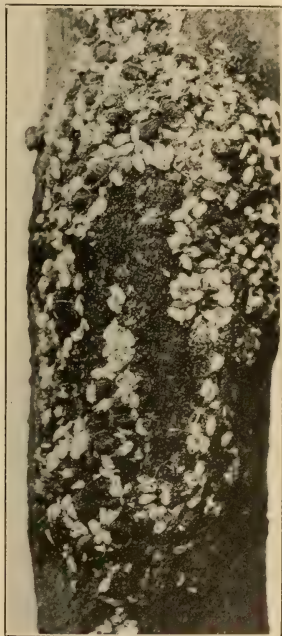


Fig. 100.—The European elm scale, *Gossyparia ulmi* (Linn.). Cocoons of the males in January. Natural size. Taken at Stockton by Wm. Garden. (Original)

⁷⁴Doten, S. B., Mo. Bul. Cal. Hort. Com., I, pp. 89-100, 1912.

the pest, if thoroughly done.⁷⁴ Crude oil emulsion, miscible oil sprays and lime-sulphur (1-9), when the trees are dormant, are also recommended.



Fig. 101.—The European elm scale, *Gossyparia ulmi* (Linn.), on the American elm. Adult females as they appear in May and June. Natural size. (Original)

Natural Enemies.—Dr. A. J. Cook reports the two-stabbed ladybird beetle (*Chilocorus bivulnerus*) as preying upon the European elm scale at San Rafael.

THE ARAUCARIA ERIOCOCCUS

Eriococcus araucariæ Maskell

(Fig. 102)

Description.—The female body is greenish-yellow with two prominent anal lobes, each terminated with quite a long hair or spine. The mature insect is enclosed in an oblong, white felt-like sac, as shown in Fig. 102. The average length of the sac is about $\frac{1}{10}$ inch.

Life History.—The eggs are laid in the white egg-sac which envelops the female and the young escape and settle upon the branches

⁷⁴Doten, S. B., Mo. Bul. Cal. Hort. Com., I, pp. 89-100, 1912.

as soon as hatched. They collect in great numbers and secrete large quantities of honey-dew, furnishing ample food for the black smut fungus. There is but one brood a year.



Fig. 102.—The araucaria Eriococcus, *Eriococcus araucariae* Mask., on Norfolk Island pine. Enlarged twice. (Original)

Distribution.—This pest was imported into this State and has become generally distributed throughout all parts.

Food Plants.—The Norfolk Island pine, *Araucaria excelsa* and *A. bidwillii* are the common food plants.

THE OAK ERIOCOCCUS⁷⁵

Eriococcus quercus (Comstock)

(*Rhizococcus quercus* Comstock)

(Fig. 103)

Description.—The body of the female is dark wine-colored or purplish and is enveloped in an oval, white felt-like sac $\frac{1}{4}$ inch long. Fig. 103 shows the general appearance of the sacs very well.

⁷⁵The greasewood Eriococcus, *E. adenostoma* Ehrh., which is common on greasewood throughout the State, greatly resembles the oak Eriococcus in size, color and shape.

Life History.—The winter is spent in a half-grown condition, maturity being reached early in summer. The scale collects in small compact colonies, which are easily located by the white sacs in which the eggs are laid. There appears to be but one brood a year.

Distribution.—This scale is widely distributed throughout the central part of the State.

Food Plants.—The black, valley and other oaks, bilberry, gallberry and grass are attacked.

THE CALIFORNIA COCHINEAL SCALE

Dactylopius confusus (Cockerell)

(*Coccus confusus* Cockerell)

(Fig. 104)

Description.—Infestations of this scale are easily recognized by the masses of thick, white, cottony material secreted as a covering over the bodies of the females and the white cocoons of the males. The bodies of the females are crimson red and yield a stain similar to that of the true cochineal insect. They vary from $\frac{1}{8}$ inch to $\frac{1}{4}$ inch in length. The cocoons of the males are snow white, oblong and $\frac{1}{4}$ inch long. They are usually closely massed with the females and may or may not be hidden by the cottony material.

Life History.—The species is more noticeable during the winter months, from November to February, when the eggs are laid. The young begin to hatch in early spring and continue for several months, there being a single uneven annual brood.

Nature of Work.—This coccid feeds upon the cactus plants, often entirely covering them and causing them to turn yellow and sickly, or completely killing them. Small plants may be greatly stunted or disfigured by their attacks.

Distribution.—The California cochineal scale is quite commonly distributed throughout the southern part of the State, from Santa Barbara to San Diego counties.

Food Plants.—The wild species of *Opuntia* are the preferred hosts, but the scale has also been taken upon *Echinocactus* sp. and an undetermined cactus which were imported from Mexico to Ventura, California.

Control.—Dipping young offshoots or plants in carbolic acid emulsion or a combination of carbolic acid, crude oil or kerosene emul-



Fig. 103.—The oak Eriococcus, *Eriococcus quercus* (Comst.), on black oak. Enlarged twice. (Original)

sions and tobacco decoction, or spraying infested plants repeatedly with these, will give good results, if the work is thoroughly done.

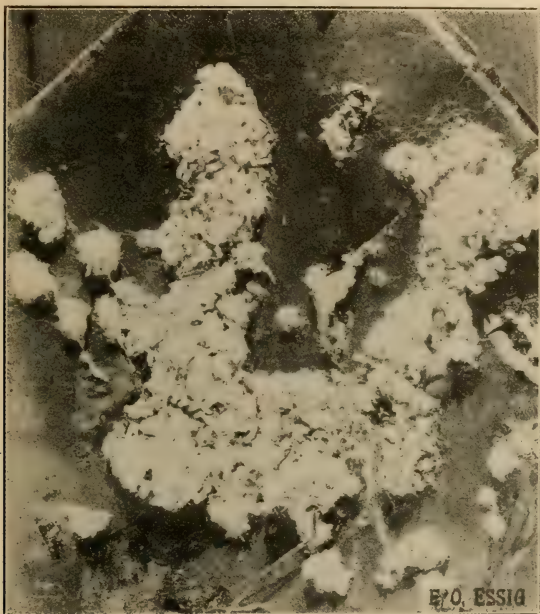


Fig. 104.—The California cochineal scale, *Dactylopius confusus* (Ckll.), on *Opuntia*. Natural size. Collected in San Diego by J. A. Prizer. (Original)

Natural Enemies.—The natural enemies of this scale are quite numerous and play a very important part in keeping it in subjection. The following are recorded by Hunter, Pratt and Mitchell:⁷⁶ the ladybird beetles, *Chilocorus cacti* Linn., *Cycloneda munda* Say, *Erochomus latiusculus* Casey, *Exochomus marginipennis* Lec., *Hyperaspis cruenta* Lec., *Hyperaspis trifurcata* Schaeffer, *Scymnus hornii* Gorham, *Scymnus læwii* Mulsant and the lepidopterous insects, *Latilia coccidivora* Comst., *Saluria ardiferella* Hulst. and *Zophodia dilatifasciella* Ragonot.

THE MARLATT SCALE

Phanicooccus marlatti Cockerell

(Fig. 105)

Description.—The adult females are dark wine-colored and secrete partially over and around themselves a white waxy material similar to that made by the European elm scale. The bodies are oval in form and

⁷⁶Bul. No. 113, Bur. Ent. U. S. Dept. Agric., p. 24, 1912.

about 1-25 inch long. They are massed in large colonies at the base of the unfolding leaves (Fig. 105), where they are thoroughly protected from ordinary measures of control.

Life History.—Very little of the true life history of this coccid is known, except that it is a very troublesome pest to the date palm. The females give birth to living young, which appear in great numbers in the early spring. These seek the base of the palm leaves, where they are thoroughly protected. Gradually the legs disappear and white wax is secreted to cover and protect the naked body. The male is unknown. The prolificacy of this species is a pronounced characteristic.

Nature of Work.—As above stated, the females congregate in large colonies at the bases of the tender unfolding leaves, which are often deformed and so injured as to greatly hinder growth.

Distribution.—The Marlatt scale is limited in the southern part of the State to Riverside and Imperial counties, where dates are commercially grown.

Food Plant.—All stages feed at the base of the leaves of the commercial date palm.

Control.—Carbolic acid emulsion poured in large quantities at the bases of the leaves until the trunk is thoroughly saturated has given very good results, according to former County Horticultural Commissioner W. H. Wilsie of Imperial County. Professor R. H. Forbes of the Arizona Agricultural Experiment Station reports to have controlled the pest by burning over the palms with a gasoline torch.⁷⁷ At a special meeting of the California date growers in Los Angeles, November 9th, Mr. Bruce Drummond of the United States Department of Agriculture stated that by far the best remedy for controlling the Marlatt and date palm scales on the old palms, and especially the offshoots, is a spray composed of the following: liquor cresolis compositus 49 per cent, 1 quart and distillate (about 32 degrees), 4 quarts. These are thoroughly mixed to form a stock solution and diluted 1 part to 50 parts of water for use. The offshoots are completely immersed for some minutes. This mixture should be used within six hours after preparation, as it soon deteriorates.



Fig. 105.—The Marlatt scale, *Phenacoccus marlattii* Ckll. Immature females feeding on the opening leaves. Natural size. Collected in Imperial County by Geo. P. Weldon. (Original)

⁷⁷Jr. Ec. Ent. VI, pp. 415-416, 1913.

THE GOLDEN MEALY BUG⁷⁸*Pseudococcus aurilanus* (Maskell)(*Dactylopius aurilanus* Maskell)

(Fig. 106)

Description.—The body is deep red and covered with bright yellow or golden flocculent, waxy secretion. This species has no prominent anal appendages. The males are very minute and dark purple in color. The dark-red or wine-colored eggs are deposited in loose masses of yellowish cottony wax. The young and adults move slowly and feed on the branches, crowding down among the needles or leaflets, often in great numbers.



Fig. 106.—The golden mealy bug, *Pseudococcus aurilanus* (Mask.), on the small twigs of the Norfolk Island pine. Enlarged twice. (Author's illustration, P. C. Jr. Ent.)

Nature of Work.—The young and adults feed upon the younger twigs near the tips of the branches and secrete a large amount of honey-dew, which affords growth for the black smut fungus.

Distribution.—The golden mealy bug is distributed throughout the State in greenhouses and in the open in the southern part.

Food Plants.—The Norfolk Island pine (*Araucaria excelsa*), Bidwill's araucaria (*Araucaria bidwillii*), *Agathis ovata* and *A. vitiensis* are attacked.

Control.—Control measures are the same as for the citrus mealy bug.

⁷⁸The diplacus *Ceroputo*, *Ceroputo yucca* (Coq.), greatly resembles the mealy bugs, but is separated by a small tooth on the inside of the claw at the extremity of the legs. The white wax is arranged in thick plates. It attacks banana, black sage, *Ceanothus* sp., *Lantana*, lemon, lime, *Mesembryanthemum* sp., bush monkey flower, California sage and yucca.

BAKER'S MEALY BUG⁷⁹*Pseudococcus bakeri* Essig

(Fig. 107)

Description.—The bodies of the adult females are light gray to bluish-gray and covered with a thick, white, waxy powder which entirely hides the color. The lateral filaments are very short, while those at the anal end are from one fourth to one half as long as the body. The eggs are oval, pale yellow and laid in loose, white, cottony masses.⁸⁰



Fig. 107.—Baker's mealy bug, *Pseudococcus bakeri* Essig; on pear. Twice enlarged. (Original)

Life History.—The eggs are deposited in loose cottony masses similar to those of the citrus mealy bug. This insect does not multiply nearly as rapidly, however, as the citrus species.

Nature of Work.—The young and adults feed upon the bark, foliage and fruit, but prefer the new bark around wounds. They also feed upon the roots under the ground.

Distribution.—Baker's mealy bug is apparently quite widely distributed throughout the State. The author has collected it in the southern and central parts.

Food Plants.—Apple, buckeye, elder, English ivy, *Grevillea*,

lemon, Mexican orange, nightshade, orange, pear, potato, potato vine, Japanese quince, wild sunflower, English walnut, grape and willow are among the hosts.

Control.—Control measures are the same as for the citrus mealy bug.

THE CITRUS MEALY BUG

Pseudococcus citri (Risso)(*Dortheisia citri* Risso)

(Fig. 108)

Description.—The bodies of the adult females are light yellow, completely covered with a thick, white, waxy secretion and from $\frac{1}{4}$

⁷⁹This coccid was named the "Walnut Mealy Bug" in the previous edition and changed because the large number of hosts attacked made it a misnomer.

⁸⁰The mealy bug taken on the citrus trees at Upland, Cal., and designated as Baker's mealy bug by the writer, differs considerably from the original type found in Ventura County. On the dorsum there are four distinct rows of small depressions, the two median rows being quite large. These depressions cause corresponding ridges. The anal wax appendages are thicker and enlarged at the base. They form a sharp angle much as the anal filaments of *Pseudococcus crawii* (Coq.). In other respects this species greatly resembles the Ventura form.

to $\frac{3}{8}$ inch long. The lateral filaments are short but distinct and the anal filaments are only slightly longer, being less than $\frac{1}{3}$ the length of the body. The eggs are oval, light yellow and laid in large, loose, white, cottony masses. The males are pale, delicate two-winged insects with two long, white anal filaments. Their cocoons are elongate, constructed of thin white cottony material and about $\frac{1}{4}$ inch long. They are located among the egg-masses and young on the leaves, fruit and bark.

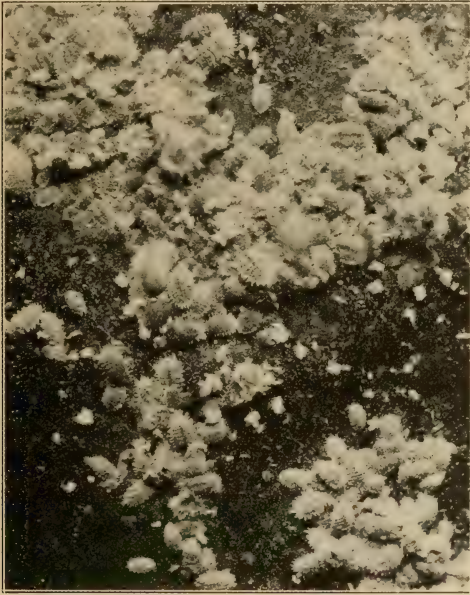


Fig. 108.—The citrus mealy bug, *Pseudococcus citri* (Risso). Mature females and egg masses on lemon. Enlarged three times. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

Life History.—The eggs are deposited in loose cottony masses by the females upon the food plants, mostly during the late fall and winter months, though some may be laid in summer. The young, upon hatching, move about very freely, seeking suitable feeding places, as the tender foliage and young fruit. The females continue to move at will throughout their existence, but the young males soon spin a small white cocoon in which to pupate. Transformation requires but a short time, the two-winged males emerging when the females are about one third or half grown. After mating the males die and the females continue to develop for some weeks or months before egg-laying begins.

During the spring months the young are to be found in great numbers, but by summer they have so hidden themselves as to give the general impression that the pest leaves the trees during that period. In the fall the adults begin to deposit the large masses of eggs which make them more conspicuous. The entire strength of the female is converted into eggs, only the shriveled and dry skin remaining after all have been deposited.

The insect hibernates in the adult and egg stage, but due to the uneven hatching caused by the warm weather in the southern part of the State, practically all stages of the young and the adult males and females may be also abundant during the winter months.

Nature of Work.—This is a most destructive insect in the green-houses, ornamental gardens and citrus orchards. It attacks the roots, bark, fruit and foliage, and due to its great numbers, often ruins the plants, fruit and trees. On the fruit it masses in great clusters and is often found in the navels of the oranges, so that it can not be easily removed. The infested leaves and young fruit may drop prematurely because of the severe attacks. Large quantities of honey-dew are secreted, affording a growing medium for the black smut fungus which covers the tree. In short, the work of the pest is exceedingly harmful and disgusting wherever it may be found.

Distribution.—The citrus mealy bug is probably more widely distributed throughout the State than any other mealy bug. It has been recorded as occurring in many of the northern counties, most of the central and southern citrus growing counties, excepting Tulare, San Bernardino and Riverside.

Food Plants.—This insect is an omnivorous feeder, attacking the following plants: Rex begonia, *Bignonia*, bottle-brush, *Bouvardia*, *Cestrum*, citron, coffee, *Coleus*, cotton, deer-brush, ferns, fuchsia, geranium, grape, grapefruit, English ivy, leadwort (*Plumbago*), moonflower, nettle, nightshade, oleander, orange, trifoliate orange, Guadalupe palm, passion vine, peony, poinsettia, potato vine, pumpkin, redwood, *Strelitzia gigantea*, *S. regina*, *Tacsonia jasminoides*, tangerine, tobacco, umbrella plant, carob and wandering Jew.

Control.—The cottony, wax material secreted by the mealy bugs renders them resistant to most of the methods employed in the control of other scale insects.

Spraying.—In all of the spraying experiments conducted it was found that an oil emulsion, which would readily dissolve the cottony wax, gave the best results, and the work then resolved itself into the selection of a spray that would not only give good efficiency in killing the mealy bugs, but which would cause less injury to the fruit and foliage of the trees and would be the least expensive. The spray that more nearly fulfilled these requirements proved to be the carbolic acid emulsion, prepared as follows:

Water	40 gallons
Whale-oil soap	40 pounds
Crude carbolic acid	5 gallons

The water should be brought to the boiling point in an iron kettle and the soap thoroughly dissolved in it. After this add the crude car-

solic acid and boil for ten or fifteen minutes. The resulting mixture should be a thick, light, creamy emulsion. For orchard use, 1 gallon of this stock emulsion is added to every 20 gallons of water, the resultant spray being milky-white in color.

There are several commercial sprays upon the market which the writer has not had an opportunity to experiment with, but many of the growers in California have used them, some with good and some with poor success, as we might expect from the use of any sprays.

The best time to spray for mealy bugs appears to be during the fall, winter and spring months, between October and March, when the eggs are being laid, the young hatching and the insects are more in evidence than at any other time of the year. At this season the citrus trees are also more or less dormant and are better able to withstand the sprayings than during the summer months.

Fumigation.—From all the experiments there seems to be a common belief that fumigation is the most efficient and economical means of commercial control in the orchards, and that by repeated applications small infestations might even be entirely eradicated. It has also been demonstrated that a repetition of small doses, one half to three fourths or full schedule No. 1, has usually given as good results with the least injury to the trees as the excessive doses which were thought to be best in the first investigations. In Ventura County the writer obtained good results by using the three fourths schedule No. 1, making a second charge at the end of the first hour, thus using two doses at hourly intervals, making the entire exposure two hours.

Natural Enemies.—There are many natural enemies of the citrus mealy bug, including the hymenopterous parasites (*Chrysoplatycrus splendens* How., *Cheiloncirus dactylopii* How.)⁸¹ the ladybird beetles, the mealy bug destroyer (*Cryptolamus montrouzieri* Muls.), the two-spotted ladybird beetle (*Scymnus bipunctatus* Kugel.), *Scymnus guttulatus* Lec., the margined Scymnus (*Scymnus marginicollis* Mann.), the clouded Scymnus (*Scymnus nebulosus* Lec.), the small brown ladybird beetle (*Scymnus sordidus* Horn), the two-stabbed ladybird beetle (*Chilocorus bivulnerus* Muls.), *Hyperaspis lateralis* Muls., the black ladybird beetle (*Rhizobius ventralis* Er.) and *Lindorus lophanthus* Blaisd.; the neuropterous insects, the green lacewing (*Chrysopa californica* Coq.) and the brown lacewing (*Symphorobius angustus* Banks); and the two dipterous insects, *Leucopis bella* Læw and *Baccha lemur* O. S.

⁸¹P. H. Timberlake considers this insect as a secondary and not a primary parasite.

THE WHITE SAGE MEALY BUG

Pseudococcus crawii (Coquillett)(*Dactylopius crawii* Coquillett)

(Fig. 109)

Description.—The bodies of the females are light yellow and covered with thick plates of white cottony material which entirely hides the color. The lateral filaments are very distinct, being about one fourth as long as the width of the body. The anal filaments vary from one third to one half the length of the body. They usually form a sharp angle at the posterior end, and in some cases the tips are curved inwardly.

Life History.—The young are brought forth alive in great numbers. The females usually settle on the leaves, which are slightly curled to afford protection. This species is most abundant during the months of May, June and July and is rarely found at other times.

Nature of Work.—This mealy bug works upon the larger stems near the surface or under the ground and upon the leaves, which are often entirely covered with them. The latter are also curled by the attacks.

Distribution.—It occurs throughout the white sage belt of southern California.

Food Plant.—The California sage and white sage are the only recorded hosts.

Natural Enemy.—The mourning Hyperaspis (*Hyperaspis marrens* Lec.) preys extensively upon this mealy bug.



Fig. 109.—The white sage mealy bug, *Pseudococcus crawii* (Coq.), on leaf of white sage. Enlarged three times. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

THE LONG-TAILED MEALY BUG

Pseudococcus longispinus (Targ.)(*Pseudococcus adonidum* Westwood)

(Fig. 110)

Description.—The bodies of the mature females vary from light yellow to gray and are entirely covered with fine, white, powdery wax. The lateral filaments are slender and from one fourth to one half the width of the body; the anal filaments are very conspicuous and are

usually as long or longer than the body. These gave rise to the common name and easily distinguish the insect from all other species in the State.

Life History.—No eggs are laid by this species, the young being born alive. Several generations appear each year, in fact, in the southern part of the State the breeding extends practically throughout the entire year. The life cycle occupies about two months.

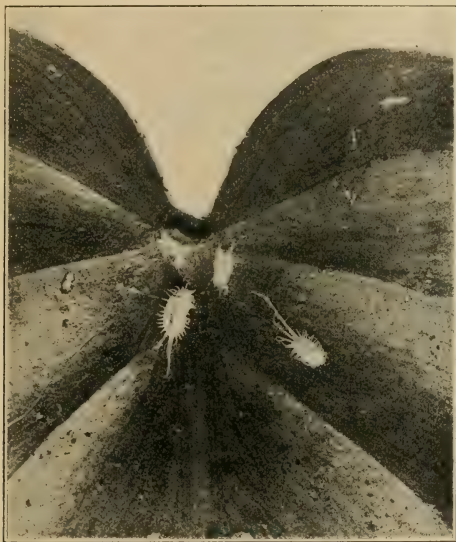


Fig. 110.—The long-tailed mealy bug, *Pseudococcus longispinus* (Targ.). Enlarged twice. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

Nature of Work.—This species attacks all parts of the host, but is usually found among the leaves, especially of such plants as the dracenas, which are often very seriously infested. Black smutting always accompanies severe attacks.

Distribution.—It occurs generally throughout the State, but is particularly bad in greenhouses and ornamental gardens.

Food Plants.—A large list of plants are attacked by the long-tailed mealy bug, among which are the following: Rex begonia, calla, *Cineraria*, citron, *Coleus*, croton, dracena, ferns, fig, *Flacourtia sepiaria*, fuchsia, grapefruit, grape, guava, lemon, lobster cactus, mango, moonflower, *Nephrodium*, oleander, *Opuntia*, orange, Guadeloupe palm, plum, primrose (*Primula obconica*), sago palm, *Stangeria schizodon*, *Strelitzia gigantea*, umbrella plant, carob and *Zamia*.

Control.—Control measures are the same as recommended for the citrus mealy bug.

THE KENTIA MEALY BUG

Pseudococcus pseudonipæ (Cockerell)

(*Dactylopius pseudonipæ* Cockerell)

Description.—This species is readily distinguished from the other mealy bugs by the cream-colored flocculence or wax which is not smoothed over the body but arranged on the segments in rows of small patches. The bodies are rich amber which blends with the creamy color of the flocculence. The males are pale yellow.

Nature of Work.—This species attacks all parts of the host but is more often found upon the undersides of the leaves.

Distribution.—It occurs in greenhouses in many parts of the State and sometimes works in the open in the southern sections.

Food Plants.—The kentia and coconut palms are the only recorded hosts.

Control.—This insect may be controlled with the same measures as are recommended for the citrus mealy bug.

SMITH'S RIPERSIA

Ripersia smithii Essig

(Fig. 111)

Description.—This species is closely allied to and looks very much like the mealy bugs, but differs by having a small tooth on the inside of the claw and the seven-jointed antennæ. The bodies are yellow or pinkish, rather slender, entirely covered with white cottony wax and $\frac{1}{12}$ inch long.

Life History.—The life history differs little from that of the mealy bugs.

Nature of Work.—All stages work inside the stems and at the bases of the leaves of the host.

Distribution.—This coccid is quite common throughout the southern part of the State.

Food Plant.—The wild rye is the only recorded host. This grass is very common around orchards and many growers have believed the scale infesting it to be the citrus mealy bug.

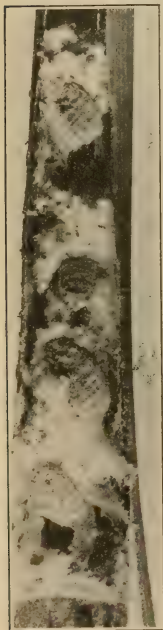


Fig. 111.—Smith's Ripersia, *Ripersia smithii* Essig. Adult females and egg masses in stalk of wild rye. Collected at Ventura by S. H. Essig. (Original)

THE COTTONY BAMBOO SCALE

Antonina cravi Cockerell

(Fig. 112)

Description.—The full-grown female scales are completely covered with a thick, compact white, cottony coat, which makes them very conspicuous. The body proper varies from $\frac{1}{8}$ inch to nearly $\frac{1}{4}$ inch long, is broadly oval or rounded and deep purplish-red in color. The females collect in colonies, forming large cottony masses in the leaf-axils of the canes.

Life History.—Fully-matured females appear in May and June and give birth to young, which settle upon the leaves and tender growth, where they remain for some months, gradually working their way to the leaf axils of the harder growth during the winter. They are more in evidence during the spring months, when maturity is reached and the bodies are covered with the cottony material.

Nature of Work.—When abundant the cottony bamboo scale becomes quite injurious and renders the host unsightly and stunts growth. It is more likely to be found upon small suckers than upon the large hardy plants.

Distribution.—This insect has often been taken in quarantine. It now occurs in many greenhouses and gardens where bamboo is grown and is confined to central and southern parts of the State. The writer collected large quantities of it in a private garden in Ventura.

Food Plant.—The bamboo is the only recorded host plant.

Control.—Due to the thick cottony covering it is exceedingly difficult to kill the adults, but frequent spraying with oil emulsions or soap solutions will eliminate the young as fast as they appear. The sprays recommended for the citrus mealy bug may also be used with good results.

COCCINÆ (Subfamily)

The members of this subfamily may be grouped as follows: those having rather soft, naked, flat bodies and retaining the power of locomotion throughout the entire life cycle, such as the soft brown and the gray citrus scales; those having naked, nearly hemispherical bodies in which the epidermis is hardened into a thick chitinous wall and retaining the power of locomotion only in the younger stages, such as the black and hemispherical scales; and those having the bodies naked entirely or partially covered with a thick waxy or cottony secretion and retaining the power of locomotion only in the younger stages, as the cottony maple and the wax scales.



Fig. 112. — The cottony bamboo scale, *Antonina crawi* Kll. Mature females on bamboo. Enlarged twice. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

THE FRUIT-TREE PULVINARIA

Pulvinaria amygdali Cockerell

(Figs. 113, 114)

Description.—The body of the mature female is flat, oval and yellow or reddish-brown. It is usually covered with fine, fluffy, white,

cottony material which is very delicate. At one end of the body is constructed a more compact white cottony egg-sac. The length of the body and egg-sac is nearly $\frac{1}{2}$ inch. The eggs are very minute, oval or oblong and almost pearly white. When massed together they appear light yellow. The young are light yellow or brownish, naked and very flat. The half-grown or nearly mature female is also entirely naked, somewhat elongated, convex and light yellowish-brown, gray or dark with darker, transverse, broken bands and a yellow longitudinal line on the dorsum. The surface is quite rough and plainly segmented. The length varies from $\frac{1}{4}$ to $\frac{3}{8}$ inch.



Fig. 113.—The fruit-tree Pulvinaria, *Pulvinaria amygdali* Ckll. Half-grown females as they appear on the twigs in April and May. Slightly enlarged. (Original)

mented. The length varies from $\frac{1}{4}$ to $\frac{3}{8}$ inch.

Life History.—The winter is spent in a half-grown condition.

Maturity is reached in April and May, when the females secrete the cottony covering and egg-sacs which are filled with hundreds of tiny eggs. The hatching period covers about two months, from the middle of April to the middle of June, but most of the young appear in May. They usually settle first upon the leaves, a few however are content to feed



Fig. 114.—The fruit-tree Pulvinaria, *Pulvinaria amygdali* Ckll. Mature females on prune leaves. Natural size. (Original)

upon the tender bark near the tips of the shoots. Before the leaves begin to fall, great numbers move to the small twigs, where the winter

is passed in a somewhat dormant half-grown condition. When the leaves and fruit appear in the spring a large number of the hibernating forms move upon them so that the leaves are often generally and the fruit occasionally infested with the nearly or fully-matured females. There appears to be but a single rather drawn-out brood a year.

Nature of Work.—This scale feeds upon the leaves, bark and fruit, producing considerable honey-dew. It has not, however, proved to be a pest of any importance in the State so far.

Distribution.—The fruit-tree *Pulvinaria* had not been known to exist in the State before 1910, when it was collected in Los Angeles County by C. H. Vary. It has since been taken in considerable numbers in Yolo and Tehama counties, being more abundant at Corning, in the latter county, than in any other locality in the State.

Food Plants.—As the common name implies this is a fruit-tree pest, having been recorded only on apple, peach, plum and prune trees. The prune is the preferred host in California.

Control.—So far control measures have been unnecessary. In case, however, that it should become a pest of economic importance the treatment as recommended for the European fruit *Lecanium*, employed in the winter when the scale is in the half-grown condition, will doubtless give the desired results.

COTTONY MAPLE OR VINE SCALE

Pulvinaria vitis (Linnaeus)

(*Coccus vitis* Linnaeus)

[*Pulvinaria innumerabilis* (Rathvon)]

(Fig. 115)

Description.—The bodies of the females are rather flat, oblong in shape and yellowish or dark brown in color. The egg-sac, which is secreted posteriorly, is composed of a fine, white, cottony material oblong in shape and from two to three times as long as the body. The egg-sac and body together are about $\frac{1}{4}$ inch long. The eggs are very small, oval and from white to yellow in color.

Life History.—The eggs are deposited in the large, loose, cottony sacs, which are secreted by the females. The young settle on the leaves and smaller limbs. The males appear late in the fall to mate and die. In the spring the females increase very rapidly and after egg-laying shrivel and die. There is but one generation a year.

Nature of Work.—During the summer the young may be found upon the leaves and tender twigs. When the leaves begin to harden and fall in the autumn the young scale moves to the younger twigs, where they remain throughout the winter and where nearly all reach maturity. In the spring, however, when the leaves appear a few move again to them, where they remain until full-grown. Serious infestations greatly lessen the vitality of the trees and the large amount of honey-dew makes them very unsightly.

Distribution.—This scale, though seldom as troublesome in this State as in the Eastern states is quite widely distributed.

Food Plants.—The following plants are attacked: alder, apple, beech, blackberry, box-elder, boxwood, buckeye (*Esculus flava*), cur-

rant, elm, euonymus, grape, gooseberry, hackberry, hawthorn, lilac, linden, locust, honey-locust, maple, mountain ash, mulberry, oak, orange, osage orange, peach, pear, plum, poplar, quince, rose, sarsaparilla (*Aralia japonica*), *Spiræa*, sumach, sycamore, *Viburnum dentatum*, willow and woodbine (*Ampelopsis veitchii*).



Fig. 115.—The cottony maple or vine scale, *Pulvinaria vitis* (Linn.). Mature females on maple twigs. Larvæ of *Hyperaspis signata* Oliv., on leaf at the left. Natural size. The specimens were received from John J. Davis, Lafayette, Ind. (Original)

Control.—Kerosene and carbolic acid emulsions, or resin wash, applied when the young are hatching, will aid in reducing the coming broods.

Natural Enemies.—There are many natural enemies preying upon this scale, including the ladybird beetles, *Rhizobius ventralis* Er., *Hyperaspis signata* Oliv. and the internal parasites, *Coccophagus lecanii* and *Microterys flavus*. *Hyperaspis signata* Oliv. does not occur in California.

THE JAPANESE OR MEXICAN WAX SCALE

Ceroplastes ceriferus (Anderson)

(*Coccus ceriferus* Anderson)

(Fig. 116)

Description.—The bodies of the adults are covered with thick, white wax, causing them to appear like lumps of dough stuck to the branches.

The body proper is black and about the size of a garden pea, with a prominent posterior tubercle or pygidium. The waxy covering is very thick, making the diameter of the scale from $\frac{1}{4}$ to $\frac{3}{4}$ inch.

Life History.—The life history is practically the same as that of *Ceroplastes floridensis* Comst.

Nature of Work.—The young first settle upon the leaves and branches, but later those on the former move to the branches, which may be entirely covered.

Distribution.—This scale occurs in very limited numbers throughout the State in greenhouses, and is often taken in quarantine from Japan, Mexico, India, Australia, Ceylon, Hawaiian Islands and South America.

Food Plants.—Camellia, *Gardenia*, *Hibiscus*, mango, *Myrica cerifera*, orange and tea are attacked.

Control.—Control measures are the same as for *Ceroplastes floridensis* Comst.

THE BARNACLE SCALE

Ceroplastes cirripediformis Comstock

Description.—This scale greatly resembles the Florida wax scale in shape. The body is dark red or brown, and the white waxy covering is mottled with shades of gray. There is a short spine-like projection at the posterior end of the body, which is hidden by the wax. The length is $\frac{1}{5}$ inch, width $\frac{1}{6}$ inch, and the height the same as the width. This species is larger and much more convex than the Florida wax scale.

Life History.—The eggs are reddish brown and darker than those of the *Ceroplastes floridensis*. The young are dark brown. The development and work are practically the same as that of *Ceroplastes floridensis*.

Nature of Work.—The young and adults work upon the leaves and smaller branches of the hosts.

Distribution.—This scale has been occasionally taken upon imported plants and in greenhouses, nurseries and private gardens. It has been rarely found out of doors only in the central and southern parts of the State.

Food Plants.—China-ball tree, citron, *Eupatorium*, grapefruit, lemon, *Lignum vita*, myrtle, orange, persimmon, quince and *Solanum* sp. are attacked.

Control.—Control measures are the same as for *C. floridensis*.



Fig. 116.—The Japanese or Mexican wax scale, *Ceroplastes ceriferus* Anderson, on *Hibiscus*. Enlarged twice. (Original)

THE FLORIDA WAX SCALE

Ceroplastes floridensis Comstock

(Fig. 117)

Description.—The adult females are white or pinkish wax scales, oval in form, convex above and concave beneath and from $\frac{1}{12}$ to $\frac{1}{8}$ inch in diameter. The upper surface of the wax covering is evenly and beautifully lobed, as shown in Fig. 117. The body is red, giving the pinkish color to the somewhat transparent wax. The eggs are 1-100 inch long and dark red.

Life History.— Each female lays from 75 to 100 eggs. The young hatch beneath the scale and soon after leaving settle to feed, first upon the leaves and then upon the stems and smaller branches. The wax covering forms with the growth of the females. There are from three to four broods a year, covering a period from April to November.

Nature of Work.—The young and adult females work upon the leaves and smaller branches of the food plants.

Distribution.—This scale is usually found in ornamental nurseries, green-houses and private gardens. It was reported as taken in the southern part of the State as early as 1889.²

Food Plants.—*Andromeda*, *Anthurium*, apple, red bay, citron, custard apple, ferns, fig, gall-berry, grapefruit, guava, holly, lemon, *Lignum vita*, loquat, mango, myrtle, oleander, orange, trifoliate orange, pear, pomegranate, quince and tea are attacked by this species.

Control.—It is seldom that this insect becomes so numerous as to be destructive, but this has occurred. Spraying should be done before the waxy covering is formed. Resin wash or oil emulsions are recommended.

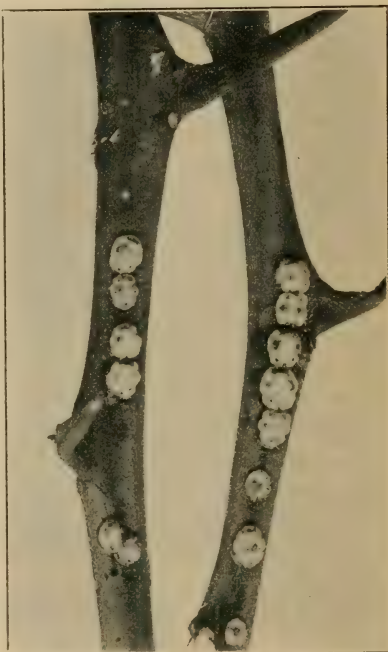


Fig. 117.—The Florida wax scale, *Ceroplastes floridensis* Comst., on trifoliate orange. Only slightly enlarged. The specimens were received from E. W. Berger, Jacksonville, Fla. (Original)

²Insect Life, I, p. 326, 1889.

THE IRREGULAR WAX SCALE

Ceroplastes irregularis Cockerell

(Fig. 118)

Description.—The mature female scale is covered with irregular, somewhat globular, white wax, averaging about $\frac{1}{4}$ inch in diameter. They are usually massed together on the twigs, as shown in Fig. 118.

Distribution.—This scale appears to be limited to the more arid regions bordering the deserts of the southern part of the State.

Food Plants.—Various species of *Atriplex* are the only recorded food plants of this scale.

Control.—The irregular wax scale is of no economic importance, but is included here because of the large numbers of inquiries constantly received from fruit growers concerning it.



Fig. 118.—The irregular wax scale, *Ceroplastes irregularis* Ckll., on *Atriplex*. Enlarged twice. (Original)

THE TESSELLATED OR PALM SCALE

Eucalymnatus tessellatus (Signoret)[*Eucalymnatus perforatus* (Newstead)](*Lecanium tessellatum* Signoret)

(Fig. 119)

Description.—The fully-matured females are quite large, flat, oval, soft scales, slightly broader posteriorly and dark brown, with many light yellow or greenish, short, transverse and longitudinal lines, giving the surface a mosaic appearance as clearly shown in Fig. 119.

Life History.—The young are born alive and settle upon the leaves and stems of the host. They move about freely throughout their

⁸⁸Other synonyms of this species are *Eucalymnatus subtessellatus* (Green) and *E. tessellatus swainsonae* (Ckll.). Davis, J. J., 27th Rept. Ind. Agrol. Exp. Sta., p. 123.

existence but when half-grown or over they seldom move unless compelled to do so by lack of food. In greenhouses the broods are overlapping, but there is usually but one or two a year.

Nature of Work.—All stages are to be found upon the leaves and stems of the hosts, but the species does not seem to be prolific enough in this State to do serious harm.



Fig. 119.—The tessellated or palm scale, *Eucalymnatus tessellatus* (Sign.), on palm leaves. Slightly enlarged. Collected at San Francisco by B. B. Whitney. (Original)

Distribution.—This scale is very commonly found in nurseries, greenhouses and private gardens throughout the State and is often taken in quarantine from other states and countries.

Food Plants.—The following plants are known to be subject to the attacks of the tessellated or palm scale: betel nut, fish-tail palm, wine palm, cinnamon, coconut, coffee, jambos, *Howea belmoreana*, *Kentia* spp., laurel, orchids, rattan palm, *Rhapis flabelliformis*, seaside grape and fortune's palm.

Control.—Spraying with carbolic acid, kerosene or distillate emulsions are recommended. In treating tender greenhouse plants these sprays should be diluted considerably to prevent injury.

THE GRAY CITRUS SCALE

Coccus citricola Campbell⁶⁴

(Figs. 120, 121)

Description.—The mature females are flat or slightly convex and regularly oval. They are larger than the soft brown scale, the largest ones being slightly more than $\frac{1}{4}$ inch long, while the average length is

⁶⁴This scale was first discovered by the writer in 1909 at Claremont, Cal. It was then thought to be *Coccus longulus* (Dougl.), and a short article on the species under that name was published in the Pomona College Journal of Entomology, Vol. I, pp. 31-32, 1909. This gave rise to the common name, "longulus scale," which is now a misnomer and which the writer has changed to the "gray citrus scale." The name "false soft brown scale" is not applicable, as there is a *Coccus pseudohesteridum* (Ckll.).

about $\frac{3}{16}$ inch. The color is gray, due to a mottled effect of dark markings on the yellow bodies. Fig. 121 shows well the color pattern. The young are first dark, or almost colorless, but gradually assume the color of the adults as they mature. The eggs are small, slightly oblong and transparent or yellowish.



Fig. 120.—The gray citrus scale, *Coccus citricola* Campbell. Overwintering young on an orange leaf. Enlarged twice. (Original)

Life History.—Maturity is reached in April and May and egg-laying begins the last of April and continues until the middle or last of June. Practically all of the young are hatched by the middle of July. The eggs either hatch as soon as laid or immediately afterwards. It is sometimes very difficult to find eggs at all and it appears that some of the eggs hatch within the body of the females and the young are born alive. The young usually settle along the midribs of the leaves or upon the very tender twigs, where many remain until mature. Others move to the branches and may be so thick as to overlap and completely hide limbs as large as one half inch in diameter. There is apparently but one uneven brood a year.

Nature of Work.—Although the leaves and petioles are generally infested, the twigs appear to be preferred by this scale and old trees are often very seriously attacked. This is in marked contrast to the habits of the soft brown scale, which prefers trees under six years of age, and then attacks principally the tender shoots and leaves. The maturing forms secrete quantities of honey-dew and cause severe smutting of the foliage and fruit. The trees are also greatly weakened by their attacks and their bearing capacities greatly lowered. In fact, this has proven to be one of the most serious of the citrus scale insects.

Distribution.—The distribution of this scale is quite large and new districts are constantly being reported. At the present time it has been found in the following counties: Orange, Los Angeles, San Bernardino, Riverside, Kern, Fresno, Tulare, Contra Costa, Solano, Placer, Tehama, Sacramento, Sutter, Yuba, Butte and Glenn.

Food Plants.—Grapefruit, lemon and orange trees are attacked by this scale. Other species of *Citrus* will undoubtedly also become infested as opportunity is afforded. Nightshade growing under or near citrus trees is also sometimes infested.



Fig. 121.—The gray citrus scale, *Coccus citricola* Campbell. Full-grown females on orange twigs. Enlarged three times. (Original)

Control.—Fumigation is apparently the best method of control and should be done as soon after all the young are hatched as possible. In the southern part of the State fumigation with one half to three fourths schedule No. 1, during the time from July 15th to August 15th, has given the best results. In Tulare County fumigation with the same dosage gave equally good results as late as November. Spraying with oil emulsions and commercial oil sprays has also given good results and is recommended when fumigation is not possible or in conjunction with fumigation.

THE SOFT BROWN SCALE

Coccus hesperidum Linnaeus

(Fig. 122)

Description.—The full-grown females are oval, flat, soft, yellow or light brown scales with a few dark markings on the very old ones. The young are transparent and correspond well with the color of the host. The male scales are very slender, smaller and lighter in color than the mature females. The adult males are yellow and exceedingly minute two-winged insects.

Life History.—The young are born alive in great numbers and settle upon the leaves and tender branches, where they are often so crowded as to overlap. The life cycle covers from three to five months, there being several uneven broods a year.

Nature of Work.—The large amount of black smut growing upon the honey-dew secreted by this scale usually calls attention to its presence at once. All stages of the females work principally upon leaves near the midribs and on the stems and the smaller branches of the hosts. In the case of citrus trees it is usually more abundant upon young trees not more than four to six year old, although it may be rarely found upon very old ones. This is in marked contrast to the attacks of the gray citrus scale which infests the leaves and branches of young and old trees alike.

Food Plants.—This species is exceedingly common and feeds upon a large number of plants, including the following: aloe, apple, apricot, ash, banana, box-elder, camellia, *Chamadorea*, citron, clematis, fig, grape, grapefruit, *Hibiscus*, holly, India rubber, English ivy, jasmine, *Kentia*, California laurel, laurel, lemon, locust, maple, morning-glory, mulberry, myrtle, oleander, orange, date palm, peach, pear, phlox, plum, poplar, prune, *Reineckia carnea*, rose, sago palm, *Vinca* and willow.

Control.—Though not so difficult of control, the same measures are recommended as for the gray citrus scale.

Natural Enemies.—Natural enemies undoubtedly play a large part in keeping this scale from becoming a more serious pest. The internal



Fig. 122.—The soft brown scale, *Coccus hesperidum* Linn., on orange leaf. Enlarged three times. (Original)

hymenopterous parasites, *Aphyycus flavus*, *Microterys flavus*, *Coccophagus lecanii*, and *C. lunulatus* are the principal ones.

THE BROWN ELM SCALE

Lecanium canadense (Cockerell)⁸⁵

(*Lecanium caryæ canadense* Cockerell)

(Fig. 123)

Description.—The mature females are rich brown, often slightly pruinose, convex and considerably longer than wide. The surface is covered with many small ridges extending from the central apex to the margins. The average length is $\frac{1}{4}$ inch. The young are light brown and quite flat. The eggs are small, slightly oblong and white. This scale is nearest to the frosted scale, *Lecanium pruinatum* Coq., but is not quite so large, never so frosted and the surface is not so smooth.

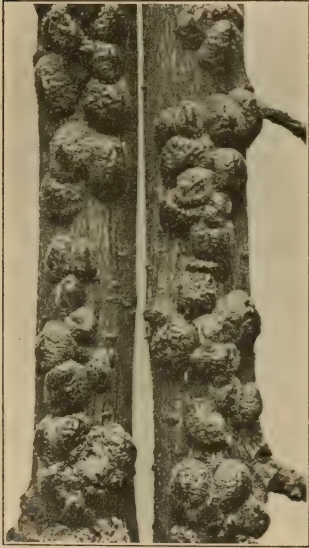


Fig. 123.—The brown elm scale, *Lecanium canadense* (Ckll.). Mature females on elm. Slightly enlarged. (Original)

Life History.—The winter is passed in a half-grown condition, maturity being reached in April and May, when egg-laying also begins. Practically all of the eggs are hatched by the first of July. The young settle principally upon the leaves at first and move to the branches before the foliage drops in the fall. Small and large limbs are infested.

Nature of Work.—The young move from the leaves to the large and small branches, where they attain maturity. They usually settle upon the undersides of the limbs and may be thick enough to completely hide the bark. Though exceedingly abundant upon many trees they do not seem to greatly inter-

fere with growth but do secrete considerable honey-dew and cause the foliage to appear very unsightly.

Distribution.—So far the writer has taken or received this scale from Tulare, Alameda, Sacramento, San Joaquin, Fresno, Los Angeles and Yolo counties. Undoubtedly its distribution is much greater.

Food Plants.—Elm trees, hickory, maple, oak and peach are infested. The elm seems to be the preferred host in this State.

Control.—Control measures are the same as for the European fruit Lecanium, *Lecanium corni* Bouché.

⁸⁵Determined by Geo. B. King, Lawrence, Mass.

THE CHERRY OR CALICO SCALE

Lecanium cerasorum Cockerell

(Fig. 124)

Description.—The full-grown scales are exceedingly large, often obtaining a diameter of $\frac{3}{8}$ inch, though the average is slightly over $\frac{1}{4}$ inch. The general shape is somewhat hemispherical and the bodies may be smooth, very irregular or lobed. The color is rich brown, mottled with creamy-white. The markings are more or less regular and constant as shown in Fig. 124. The entire surface is highly polished and shiny.

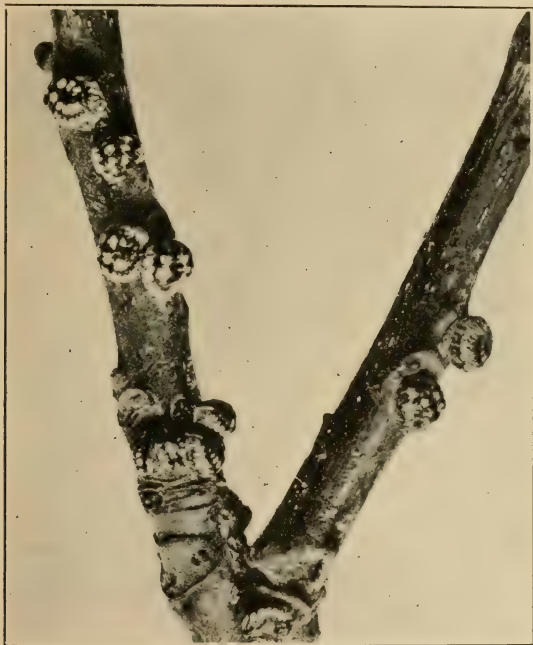


Fig. 124.—The cherry or calico scale, *Lecanium cerasorum* Ckll. Mature females on English walnut. Slightly enlarged. Collected in Contra Costa County by Geo. P. Weldon. (Original)

Life History.—The females become full-grown in March and April and begin egg-laying about the first of April. By the middle of the same month the eggs begin to hatch and continue for about thirty days. The young settle upon the leaves and tender branches, but later move to the branches before the leaves fall. Here winter is passed in a half-grown condition. There is but one rather even brood a year.

Nature of Work.—The leaves are attacked by the young, which later settle upon the branches where they mature. Large amounts of honey-dew cause smutting of the fruit and foliage of the infested plants.

Distribution.—The cherry or calico scale appears to be limited to the San Francisco Bay region, especially in Contra Costa and Alameda counties.

Food Plants.—Though this coccid has but recently been reported in California, it has already been found attacking cherry, pear, prune, Virginia creeper and English walnut.

Control.—Control measures are the same as for the European fruit Lecanium (*Lecanium corni* Bouché).

Natural Enemies.—A few specimens of *Comys fusca* were reared from this scale.

THE EUROPEAN FRUIT LECANIUM

Lecanium corni Bouché

(*Eulecanium armeniacum* Craw)

(Figs. 125, 126)

Description.—The matured females vary from amber to a dark reddish-brown, are very convex and longer than wide, being about $\frac{1}{8}$ inch long. The eggs are very small, slightly oblong and pearly white. The young are light yellow, turning reddish-brown as they grow older.

Life History.—The females become mature in April and May when great quantities of eggs are laid (Fig. 126) and the young begin to hatch. These settle upon the leaves and younger twigs, where they remain during the summer. As the leaves begin to drop many of the young scales move to the branches where they mature by the next spring. During the winter they are in the half-grown stage. This species is exceedingly prolific and the insects are often so thick as to entirely cover all of the smaller twigs. Severe infestations occur only periodically. There is but one quite even brood a year.

Nature of Work.—The abundance of the scale during certain years is often quite alarming, but seldom is it a pest for more than two successive seasons. Large amounts of honey-dew are secreted, causing smutting of the fruit and foliage. The younger twigs are infested during the winter. The scale is more easily located during April and May when they become full-grown.

Distribution.—This is a very common scale, occurring through the entire State and especially abundant in the apricot and prune growing sections.

Food Plants.—The following food plants are attacked: apple, apricot, ash, basswood, blackberry, cherry, currant, elm, gooseberry, greasewood, grape, mountain holly, osage orange, peach, pear, pecan, plum, prune, quince and Spanish chestnut.

Control.—Spraying with miscible oils or with distillate emulsion when the trees are dormant, as early as possible, gives excellent results. In rare cases it is advisable to spray before all the leaves fall.

Natural Enemies.—The internal hymenopterous parasite, *Comys fusca*, plays a very important part in the control of this scale and is undoubtedly responsible for its not being serious year after year. If the scales are examined in March and April when the eggs are laid it will be noticed that many are decidedly dark and if these are turned over no eggs will be found. In practically every such case,



Fig. 125.—The European fruit Lecanium, *Lecanium corni* Bouché. Mature females on apricot. Natural size. (Original. Photo by State Hort. Com.)

if the scale is dissected, a pupa of the parasite will be disclosed. In many instances as high as 95 per cent of the scales are parasitized. The adult parasites begin to issue about the middle of May when the eggs are hatching and at once lay their eggs in the young scales. The eggs hatch in the bodies and develop along with the scales. Even where the parasitism occurs the scale for that year mature and do all the damage of perfectly healthy ones before they are killed. Egg-laying, however, is averted and the succeeding year's brood materially decreased.

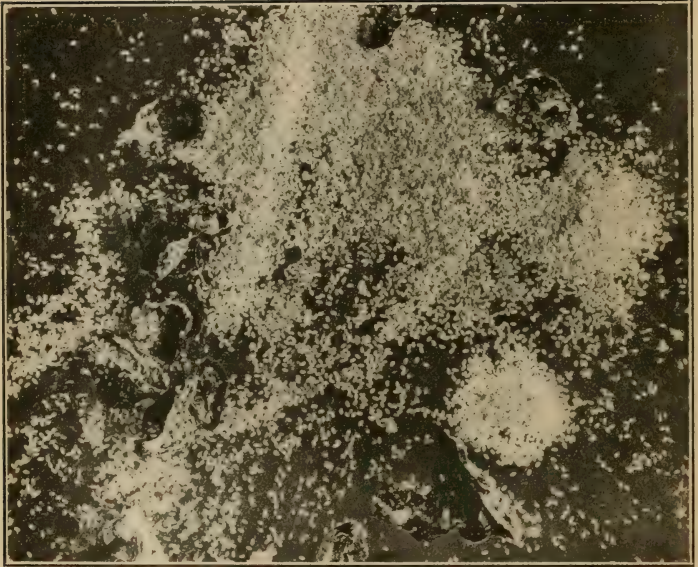


Fig. 126.—The European fruit Lecanium, *Lecanium corni* Bouché. Eggs from eight females, showing the tremendous possibilities of increasing in great numbers. Enlarged twice. (Original)

THE EUROPEAN PEACH SCALE

Lecanium persicæ (Fabricius)(*Coccus persicæ* Fabricius)(*Lecanium magnoliarum* Cockerell)

(Fig. 127)

Description.—The full-grown females of this species are rich chestnut-brown in color, oval in shape, with the ends pointed and much less convex than the European fruit Lecanium, which it greatly resembles. The length varies from $\frac{3}{16}$ to $\frac{5}{16}$ inch and the width is one fourth less.

Life History.—The life history of this scale does not differ materially from that of the European fruit Lecanium.

Nature of Work.—The scales settle upon the stems and smaller limbs and twigs in such numbers as to overlap. Like other members of the genus, the honey-dew and smutting results in the chief injury.

Distribution.—Under the name of *Lecanium magnoliarum*⁸⁶ Ckll., this scale has been known to exist at San Jose since 1897,⁸⁷ where it was first collected by E. M. Ehrhorn. In the spring of 1914 Earl Morris, horticultural commissioner of Santa Clara County, collected large numbers of the same scale on English ivy at San Jose. The pest was believed to have been introduced from Japan.

Food Plants.—The following trees are attacked: *Elæagnus angustifolia*, English ivy, ginko, gooseberry, grape, American holly (*Ilex opaca*), Japanese quince, magnolia, mulberry, nectarine, peach, pear, plum, rose and silver thorn.

Control.—Control measures are the same as recommended for the European fruit Lecanium.



Fig. 127.—The European peach scale, *Lecanium persicæ* (Fab.), on English ivy. Enlarged twice. (Original)

THE FROSTED SCALE

Lecanium pruinosum Coquillett⁸⁸

(Fig. 128)

Description.—The fully-matured females are among the largest of the common Californian unarmored scales, often being nearly $\frac{1}{2}$ inch

⁸⁶Sanders, J. G., Jr. Ec. Ent. II, p. 441, 1909.

⁸⁷Cockerell, T. D. A., Ent. News IX, pp. 145-146, 1898.

⁸⁸Sanders, J. G., Jr. Ec. Ent. II, p. 442, 1909.

long and $\frac{3}{4}$ as wide. They average, however, about $\frac{3}{16}$ inch in length and are quite convex, while the immature forms are very flat. The surface is slightly rough and covered with a fine, white powder, from which the common name is derived. The eggs are oblong and pearly white in color.⁸⁹



Fig. 128.—The frosted scale, *Lecanium prunosum* Coq. Mature females on English walnut. Natural size. Collected in Contra Costa County by Geo. P. Weldon. (Original)

Life History.—The females reach maturity and begin egg-laying in March and April, the eggs hatching from the middle of April to the middle of May. The species is exceedingly prolific and a single female may lay several thousand eggs. The young usually first settle upon the leaves; however, a large number remain upon the new growth of the branches. In the fall those on the leaves also move to the branches where all mature and begin egg-laying the next spring. There is but one brood a year. Though very prolific, this scale seldom becomes abundant enough to be a serious pest and only occasionally may control measures be necessary.

Nature of Work.—The young attack the leaves and the adults the branches, and, if abundant, secrete enough honey-dew to smut the fruit and foliage.

⁸⁹A closely allied species, the oak Lecanium, *Lecanium quercitrionis* Fitch, greatly resembles the above in size and color, but is found only on the oak. It is slightly pruinose and sometimes has a light, longitudinal stripe on the dorsum. Fig. 129.

Food Plants.—Apple, apricot, mountain ash, birch, cherry, elm, grape, hawthorn, laurel, loganberry, orange, peach, pear, plum, prune, rose, sycamore and English walnut are attacked.

Control.—Control measures are the same as for the European fruit Lecanium (*Lecanium corni* Bouché). It is seldom necessary to employ such measures for this scale, as it rarely proves a pest.

Natural Enemies.—Natural enemies must be responsible for the holding in check of this scale, as no other factors appear to enter into its not becoming more abundant and harmful. The larvæ of ladybird beetles and of the green lacewing (*Chrysopa californica*) feed upon the young. The internal hymenopterous parasite (*Comys fusca*) is by far the most effective enemy.

THE HEMISPHERICAL SCALE

Saissetia hemispharica (Targ.)

(*Lecanium hemispharicum* Targ.)

(Fig. 130)

Description.—The adults are regularly oval or hemispherical in shape and slightly over $\frac{1}{8}$ inch in diameter. The surface is polished and shining and the color light or dark brown without markings.

The eggs are very small and vary from pearly-white to cream color.

Life History.—The eggs are usually laid during the months of May, June and July and begin to hatch soon after they are laid, thus the single brood is quite uneven, stretching over a period of nearly three months. The young scales settle upon the leaves and smaller branches and do not reach maturity until the following spring or early summer, when egg-laying commences. Though often very abundant upon individual plants it has not become a serious pest outside of the green-houses, where it does sometimes prove to be a nuisance.

Nature of Work.—The young and adults work upon the leaves and branches of the host, often occurring in sufficient numbers to entirely hide the bark. On orange trees the adults are often found around the edges of the leaves, as well as upon the smaller branches. It also occurs sparingly upon the fruit.

Distribution.—The hemispherical scale is a general greenhouse pest throughout the State. In southern California it is quite common, especially in parks and ornamental gardens.

Food Plants.—Aloe, asparagus ferns, Bignonia, camellia, chrysanthemum, citron, croton, ferns, grapefruit, guava, mountain holly,



Fig. 129.—The oak Lecanium, *Lecanium quercitrionis* Fitch, on valley oak. Enlarged twice. (Original)

lemon, oleander, orange, orchids, palm, peach, rose, sago palm, pepper tree and *Zamia* are attacked.

Control.—Control methods are the same as for black scale (*Saissetia oleæ*). This species rarely requires treatment except in greenhouses.



Fig. 130.—The hemispherical scale, *Saissetia hemispharica* (Targ.). Mature females on the underside of an orange leaf. Enlarged twice. Collected at Ventura by S. H. Essig. (Original)

Natural Enemies.—The black ladybird beetle, *Rhizobius ventralis*, the egg parasite, *Scutellista cyanea*, and the internal parasites, *Comys fusca* and *Coccophagus lecanii*, aid greatly in keeping down the numbers of this insect.

THE BLACK SCALE

Saissetia oleæ (Bernard)(*Chermes oleæ* Bernard)

(Figs. 131, 132)

Description.—The fully-matured females are black, nearly hemispherical, hard scales with a distinct “H” upon the back, which appears after they have become one third or one half grown. The average matured scale is from $\frac{1}{8}$ to $\frac{1}{4}$ inch in diameter. The male scales, which are rarely observed, are very much smaller than the females. They are long, narrow, flat and nearly transparent or colorless. The adult males are light yellow and exceedingly minute. The eggs are nearly globular and yellowish-brown in color.

Life History.—The females deposit from fifty to three thousand eggs, covering a period of from two to four weeks. The majority are laid during the months of May, June and first half of July, though in some sections all stages of the insect may be found at nearly any season. Young half-grown scales are most abundant from September 15th to December 15th. The insects work principally upon the leaves of the trees, when they are young, but later are found almost wholly upon the limbs.

Nature of Work.—All stages may be found upon the leaves, fruit and stems of the hosts, but the latter appear to be preferred. Upon some plants they may be found at the base, several inches under the ground. Aside from

extracting the juices from the trees, the scales produce large amounts of honey-dew, which, being a medium of growth for the black smut fungus, causes the smutting of the fruit and foliage, which is by far the greater injury. Because of this damage and its wide distribution the black scale is generally conceded to be the most expensive pest in the State.

Distribution.—This scale is widely distributed throughout the citrus growing sections of the southern and central parts of the State. It also occurs in limited numbers in the northern part.



Fig. 131.—Black scale, *Saissetia oleæ* (Bern.). Immature and full-grown females on oleander. (Original)

Food Plants.—Almond, *Antidesma*, apple, apricot, mountain ash, aster, beech, buckthorn, camellia, *Cedrus deodara*, *Cestrum*, chrysanthemum, citron, *Duranta*, eucalyptus, fig, grape, grapefruit, *Grevillea*, *Grewia*, groundsel tree (*Baccharis*), guava, holly, mountain holly, Irish juniper, laurel, lemon, locust, honey-locust, magnolia, maple, *Melaleuca*, *Myoporum*, nightshade, oleander, olive, orange, trifoliate orange, orchids, palm, pigeon pea, pear, pepper tree, phlox, plum, pomegranate, poplar, privet, prune, rose, rubber, California sage, sumach, sycamore, tangerine, sago palm, *Thespesia* and watermelon are among the plants attacked by the black scale.

Control. — *Fumigation*: On citrus trees, fumigate with from one half to three fourths schedule No. 1, between September 1st and January 1st. If the hatch is very even and the work can be done early, the one half schedule is sufficient, but for ordinary work three fourths of the schedule is required.

Sprays: On deciduous fruit and olive trees the following sprays may be used when the scales are not more than half-grown: Water-distillate-caustic-soda mechanical mixture, miscible oils and distillate emulsions.

Natural Enemies.—The ladybird beetles, *Rhizobius ventralis*, *Orcus chalybeus*, *Olla abdominalis* and *Axion plagiatus* work upon the young scales; the parasites, *Scutellista cyanea* and *Tomocera californica* How., destroy the eggs and the internal parasite, *Aphycus flavus* How., has been reared from the male scales and *Coccophagus lecanii* attacks the young.



Fig. 132.—The black scale, *Saissetia olea* (Bern.). Scales of the males on orange leaf. Slightly enlarged. Collected at Orange by Roy K. Bishop. (Original)

THE MONTEREY PINE SCALE

Physokermes insignicola (Craw)

(*Lecanium insignicola* Craw)

(Fig. 133)

Description.—The adult females vary from reddish-brown to black, are strongly convex or almost globular with inflated base, and are irregular and unsymmetrical. The surface is smooth, shiny and covered with minute dark specks. The diameter is about $\frac{1}{4}$ inch. The immature forms are light brown and very much flatter than the adults.

Life History.—The winter is passed in the half-grown stage and maturity is reached in early summer, when the young of the next

season's brood are brought forth. There is but one uneven brood a year.

Nature of Work.—All forms attack the tips of the pine twigs, often congregating in large numbers. The young secrete much honey-dew and the trees are often rendered black and unsightly because of their presence.



Fig. 133.—The Monterey pine scale, *Physokermes insignicola* (Craw). Adult females near tip of pine twig. Enlarged twice. Collected at Berkeley by Fred Essig. (Original)

Distribution.—This species is common along the coast in the central part of the State, being especially abundant in the San Francisco Bay region.

Food Plants.—The Monterey and other pines and white fir are attacked.

Control.—Spraying in the winter with kerosene or crude oil emulsion, or with miscible oil and soap sprays is recommended for the control of this scale. A woodland nozzle is preferred to reach the high branches.

DIASPINÆ (Subfamily)

The members of this subfamily are characterized by the formation of a scale which affords protection for the body and are called armored scales. The scales of the females are circular, or nearly so, and with the exuviae at or near the center. The scales of the males are somewhat elongated, usually smaller and with the exuviae sub-central or near one end. After the first molt the insects lose their legs and antennæ, the females continuing thus throughout their existence. After the last molt the males acquire legs, wings and antennæ.

The representatives of the *Diaspinæ* are very numerous and comprise some very destructive species.

THE ORANGE CHIONASPIS

Chionaspis citri Comstock

(Fig. 134)

Description.—The female scales are elongated, blackish-brown, with gray margins and dark yellow exuviae. The male scales are very small, long and narrow and white with exuviae yellow. They are often grouped so thickly as to almost hide the females and make the branches appear white.



Fig. 134.—The orange Chionaspis, *Chionaspis citri* Comst. Nearly all those shown are the scales of the males. Twice enlarged. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

Life History.—The life history is practically the same as that of *C. euonymi* Comst.

Nature of Work.—The males and females work upon the branches, small twigs and leaves.

Distribution.—This scale occurs in many foreign citrus growing regions and is often taken in quarantine. It has been reported from San Diego County, but has evidently never become thoroughly established anywhere in the State.

Food Plants.—The favorite food plant is the orange, though other species of citrus trees are attacked as well as *Euonymus*, *Osmanthus ilicifolius* and palms.

Control.—Fumigation as for the red scale or the purple scale will easily control this pest.

THE EUONYMUS SCALE

Chionaspis euonymi Comstock

(Fig. 135)

Description.—The female scale is dirty-brown or nearly black with yellow exuvia, convex, elongated, broader posteriorly and from $\frac{1}{16}$ to $\frac{1}{8}$ inch long. The scale of the male is snow-white, very narrow, slightly shorter than the diameter of the female scale and strongly tricarinated.

Life History.—The young insects are yellow and soon settle to produce the scales of the male or female. So thick are they that plants are sometimes ruined by the females, while the same may appear to be covered with fine flakes of snow, due to the great numbers of the minute white scales of the males. The insect attacks all parts of the host and is very destructive, often completely killing entire hedges.

Nature of Work.—The males and females may be found upon all parts of the infested plants, often so thick as to overlap and completely hide the twigs.

Distribution.—In California it occurs in greenhouses or is simply taken in quarantine.

Food Plants.—*Euonymus latifolius*, *E. japonicus*, *E. europæus*, *E. atropurpureus*, *Celastrus scandens* and orange are the recorded food plants.

Control.—To control this pest spray with kerosene or distillate emulsion or resin wash every two weeks during the months of May and June, or until the scale has disappeared. The work should be done during the hatching period and care taken to see that the sprays are not strong enough to injure the foliage.

In the winter, when the plants are dormant, much stronger solutions of the same sprays or lime-sulphur (1-13) may be used with lasting effects.



Fig. 135.—The euonymus scale, *Chionaspis euonymi* Comst., on leaf of *Euonymus*. Natural size. (Original)

THE SCURFY SCALE

Chionaspis furfura (Fitch)

(*Aspidiotus furfurus* Fitch)

(Fig. 136)

Description.—The female scale is irregular and broadly pear-shaped, from white to light gray in color and 1-9 to $\frac{1}{8}$ inch long. The exuvia is yellowish. The male scale is white, very small, slender, tricarinated,

with yellow exuvia and is from 1-25 to 1-18 inch long. The eggs are very small and vary from wine-colored to purple. This scale is often confused with the oyster-shell scale, but is broader, flatter and much lighter in color. The eggs are dark, while those of the oyster-shell scale are white.

Life History.—The winter is passed in the egg stage under the old female scales. The young hatch in the spring and settle upon the limbs and smaller twigs. There is but one brood a year.

Nature of Work.—When abundant, the scale greatly stunts the growth of the trees, but seldom if ever causes death. It produces reddish discolorations on the fruit, much as does the San Jose scale.

Distribution.—The scurfy scale, though common in many

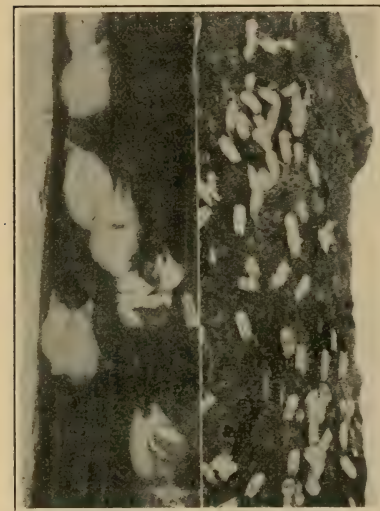


Fig. 136.—The scurfy scale, *Chionaspis furfura* (Fitch). Female scales at left and males at right. (After Quaintance and Sasser, U. S. Dept. Agric.)

of the Central and Eastern states, is exceedingly rare in California, having been reported only from the southern part.⁹⁰

Food Plants.—The following food plants are recorded: white alder, apple, Chinese flowering apple, crab apple, European mountain ash, American mountain ash, prickly ash, white ash, large-toothed aspen, buckthorn, chokecherry, wild black cherry, wild bird cherry, chokeberry, black chokeberry, red chokeberry, red flowering currant, elm, gooseberry, hawthorn, big bud hickory, horse-chestnut, peach, pear, plum, poplar, quince, Japanese quince, black cap raspberry, shad-bush, sweet gum (*Liquidambar*), black walnut and white willow.

Control.—The remedies are the same as for the San Jose scale.

Natural Enemies.—The predaceous enemies attacking the scurfy scale are the two-stabbed ladybird beetle (*Chilocorus bivulnerus* Muls.),

⁹⁰Yearbook, U. S. Dept. Agric. p. 259, 1894.

Cir. No. 121, Bur. Ent. U. S. Dept. Agric., p. 8, 1910.

Tyroglyphus malus (Shimer) and *Hyperaspis* sp. The parasitic hymenopterous enemies are *Ablerus clisiocampæ* (Ashm.),⁹¹ *Physcus varicornis* How. and *Prospaltella* sp.⁹²

LINTNER'S SCALE

Chionaspis lintneri Comstock

(Fig. 137)

Description.—This species greatly resembles the willow scale, *Chionaspis salicis-nigræ* Walsh and the pine-leaf scale *C. pinifolia* Fitch. The exuviae are very small, yellow and situated at one end. The female scales are white and broadly pyriform. The male scales are slender, white, with yellow exuviae one fourth as long as the scale, which is plainly tricarinate.

Distribution.—This species has been taken in the central part of the State

Food Plants.—Alder, arrow-wood, spice bush, white birch, dogwood, hazelnut, Juneberry and leatherwood are attacked.

Control.—The control measures, if ever necessary, are the same as for the pine-leaf scale.

THE COTTONWOOD SCALE

Chionaspis ortholobis Comstock

(Fig. 138)

Description.—The female scales are white, pyriform and generally resemble the willow scale (*C. salicis-nigræ*), but are slightly smaller and narrower, the length being about $\frac{1}{12}$ inch. The exuviae are dark yellow and located at one end of the scales. The bodies of the females are dark purple and the eggs are of the same color. The male scales are white, much smaller than the females, elongated, widest at middle and smooth. The lack of carinae in the male scales distinguishes the species from all others of the genus. The exuviae of the male scales are bright yellow.

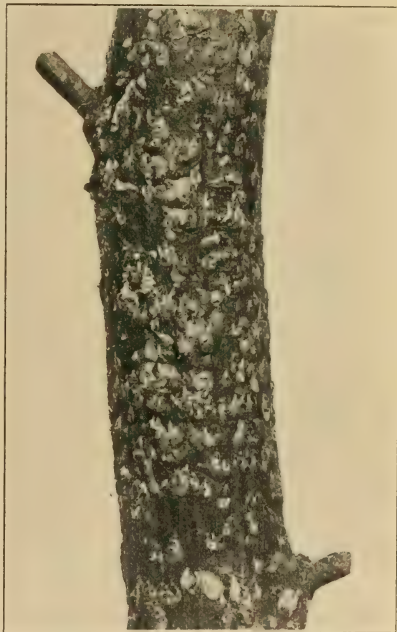


Fig. 137.—Lintner's scale, *Chionaspis lintneri* Comst., on willow. Enlarged three times. (Original)

⁹¹Yearbook, U. S. Dept. Agric. p. 254, 1894.

⁹²Cir. No. 121, Bur. Ent. U. S. Dept. Agric. p. 9, 1911.

Distribution.—This species seems to be limited to the southern part of the State, having been reported only from San Bernardino, Riverside, Los Angeles and Ventura counties.

Food Plants.—The willow is the normal food plant of this scale, but it also attacks butternut, cottonwood, honey-locust and poplar.



Fig. 138. —The cottonwood scale, *Chionaspis ortholobis* Comst., on willow. Enlarged twice. (Original)

Control.—Control measures are the same as for the pine-leaf scale (*Chionaspis pinifoliæ*).

Natural Enemies.—The two-stabbed ladybird beetle has been noted as preying upon this scale.

THE PINE-LEAF SCALE

Chionaspis pinifoliæ (Fitch)*(Aspidiotus pinifoliæ* Fitch)

(Fig. 139)

Description.—The scales of the mature females are white, narrow, pyriform or elongated, the shape being elongated and narrow if on a narrow-leaved pine and pyriform if on a wide-leaved host as the mountain nutmeg (*Torreya californica*). They average about $\frac{1}{8}$ inch in length. The exuviae are light yellow. The male scales are very narrow, half as large as the females, and pure white with yellow exuviae. The eggs are elongate, very small and white.

Life History.—The winter is passed in the egg-stage under the female scales. The eggs hatch in the spring and the young of the first brood are mature by midsummer. There are two broods a year.

Nature of Work.—This scale works only upon the needles of coniferous trees and is often so abundant as to cause the foliage to turn yellow and the tree to assume a sickly appearance.

Distribution.—The pine-leaf scale is very common throughout the entire State, occurring in the wild mountain regions as well as in the valleys.

Food Plants.—Many of the coniferous trees are attacked including the Bohtan, Corsican, digger, Monterey, red, Scotch, Soledad, sugar, Swiss stone, yellow and white pines, *Pinus torreyana*, fir, California nutmeg and spruce.

Control.—Spraying with kerosene or crude oil emulsions is recommended for ornamental trees.

Natural Enemies.—The two-stabbed ladybird beetle (*Chilocorus bivulnerus* Muls.) and other species of ladybird beetles prey upon this scale.

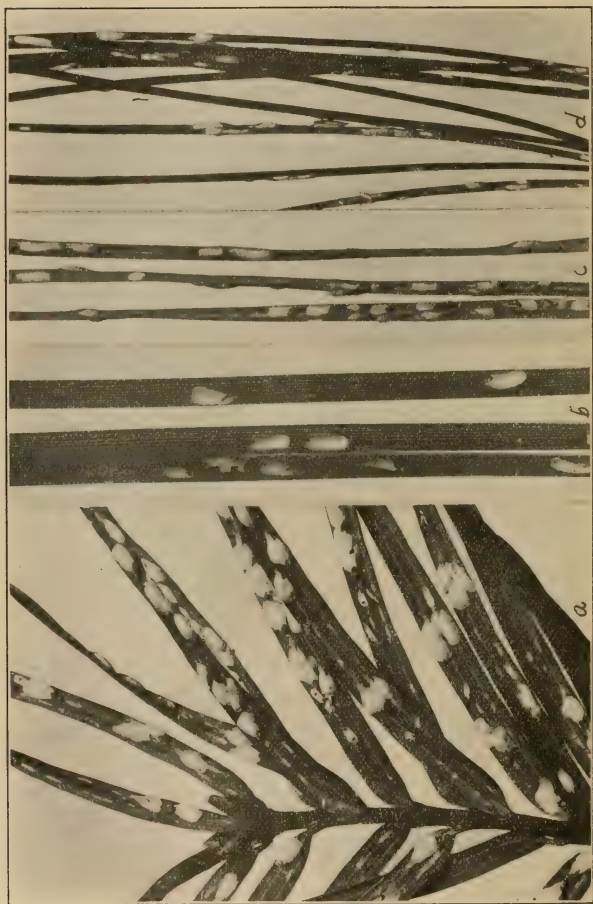


Fig. 139.—The pine-leaf scale, *Chionaspis pinifolia* (Fitch), showing the development of the scale on different hosts as follows: a, on mountain nutmeg; b, on Monterey pine; c, on yellow pine; d, Eastern yellow pine. All photographed on same scale. Enlarged twice. (Original)

THE OAK SCALE

Chionaspis quercus Comstock

(Fig. 140)

Description.—This very common scale is often a source of annoyance to horticulturists, and especially gardeners who confuse it with more serious pests. The female scales are rather long, pyriform and dark-gray with yellowish-brown exuviae. The length averages $\frac{1}{12}$ inch. The male scales are about half as large, very narrow, tricarinated and snow-white with yellow exuviae.

Distribution.—This species is quite common, having been taken by the writer in the southern, central and northern parts of the State.

Food Plants.—The coast live oak, maul oak and white oak have been observed as hosts.

Control.—Control measures are the same as for the pine-leaf scale and are only to be advised for small parks, where the cost of materials is not an important consideration.

THE WILLOW SCALE

Chionaspis salicis-nigræ (Walsh)

(*Aspidiotus salicis-nigræ* Walsh)

(Fig. 141)

Description.—The scales of the females are quite large, elongated or slightly pyriform, being widest near the middle, and pure white or light gray in color. The dorsum is only slightly convex. The exuviae are yellowish or brownish. The length of the scales varies from $\frac{1}{8}$ to $\frac{1}{6}$ inch. The male scales are much smaller, white, with yellow exuviae, faintly tricarinated and widest at the posterior end.

Life History.—The life history is practically the same as for the pine-leaf scale (*Chionaspis pinifoliae* Fitch).

Nature of Work.—The scale is a bark feeder and attacks the limbs and smaller twigs. Upon the *Ceanothus* it works around the base near the ground and often completely kills the bushes.

Distribution.—This is a very common scale in the central and northern parts of the State, especially in the Sierra Nevada mountains.

Food Plants.—Deer-brush, red-osier dogwood (*Cornus stolonifera*), big-leaf maple, poplar, shad-bush (*Amelanchier canadensis*), tulip-tree and willow are among the food plants of this scale.

Control.—Oil emulsions are recommended to control this pest.



Fig. 140.—The oak scale, *Chionaspis quercus* Comst. Males and females on twigs of the coast live oak. Enlarged twice. (Original)



Fig. 141.—The willow scale, *Chionaspis salicis-nigræ* (Walsh). The left is the eastern form on poplar and the right the western form on big-leaf maple. Enlarged three times. (Original)

THE CORD-GRASS SCALE

Chionaspis spartinae Comstock

(Fig. 142)

Description.—The female scales are snow-white with pale yellow exuviae, somewhat oyster-shaped with fine cross ridges. They are about $\frac{1}{16}$ inch long. The male scales are of the same color as the females, but are slender and faintly tricarinated.

Distribution.—This scale occurs plentifully around the San Francisco Bay, especially along the arm extending into San Mateo, Santa Clara and Alameda counties.

Food Plant.—The cord-grass (*Spartina foliosa*) is the only known host plant in California. Because it is often confused with destructive orchard and garden coccids, a description is included in this work.

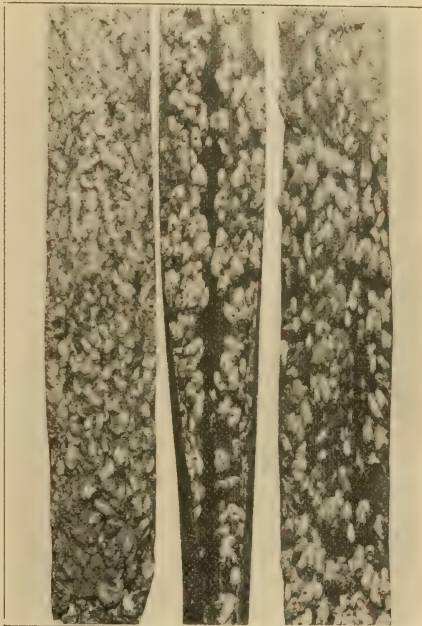


Fig. 142.—The cord-grass scale, *Chionaspis spartinae* Comst., on cord-grass. The holes were made by parasites. Enlarged three times. (Original)

THE PINEAPPLE SCALE

Diaspis bromeliæ (Kern.)*(Coccus bromeliæ* Kern.)

(Fig. 143)

Description.—The female scales are nearly circular, thin, white or light gray with yellow exuviae. The bodies are orange-yellow, sometimes with blue or purple tints. The male scales are very small, slender and white.

Life History.—There seems to be but one uneven brood a year, the young appearing in the early spring and the mature scales continuing to live through the winter. The scale usually occurs only in warm countries and in greenhouses.

Nature of Work.—This insect attacks the leaves, into which they often mine so as to hide themselves. They are also common upon the fruit of the pineapple (Fig. 143).

Distribution.—The pineapple scale occurs only in greenhouses and is often taken in quarantine.

Food Plants.—Acacia, *Billbergia zebrina*, canna, *Hibiscus*, English ivy, olive, palm, pinguin, fan palm, pineapple and sago palm are often infested with this species.

Control.—Spraying, when the pest occurs in the field, with crude oil or kerosene emulsions and miscible oils gives good results. Infested fruits should be fumigated with full schedule No. 1 or with three times this amount if complete eradication is desired.

Natural Enemies.—*Aspidiotiphagus citrinus* has been reared from this species.

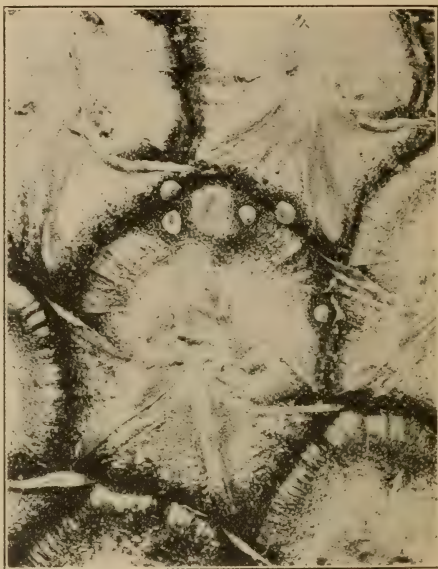


Fig. 143.—The pineapple scale, *Diaspis bromeliæ* (Kern.), on a pineapple. Slightly enlarged. Taken in quarantine by Frederick Maskew. (Original)

THE JUNIPER SCALE

Diaspis carueli Targ.

(Fig. 144)

Description.—The female scales are circular, white or light gray, with yellow central or subcentral exuviae. The diameter varies from 1-25 to $\frac{1}{16}$ inch. The female bodies are nearly circular and yellow. The male scales are snow-white, very small, narrow, with prominent median ridge and yellow exuviae. They are 1-25 inch long. The adult males are light yellow.

Life History.—The winter is passed in a half-grown condition and maturity is reached in early summer. The species is quite prolific, but there appears to be but a single brood a year.

Nature of Work.—This species infests the foliage and cones of the trees, often in such numbers as to make them appear whitewashed. The young green cones are preferred.

Distribution.—The juniper scale is quite common throughout the State, especially in parks and private gardens.

Food Plants.—Arborvitæ, *Biola orientalis*, incense cedar, common juniper, cypress, *Cupressus lusitanica*, *Juniperus chinensis*, *J. japonicus*, *J. oxycedrus*, *J. reresii*, *J. rigida* and *J. spherica* are among the recorded hosts.

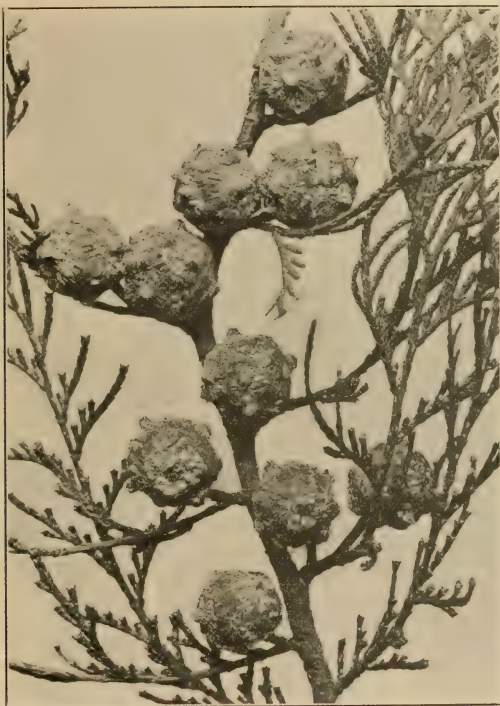


Fig. 144.—The juniper scale, *Diaspis carueli* Targ., on *Cupressus lusitanica*. Natural size. (Original)

Control.—The application of crude oil or kerosene emulsions during the winter will serve to check any damage.

THE CACTUS SCALE

Diaspis echinocacti cacti Comstock

(Fig. 145)

Description.—The scales of the females are nearly circular, thin, light gray or whitish with subcentral dark brown exuviae. The diameter varies from $\frac{1}{16}$ to 1-14 inch. The male scales are very small, slender, white with a longitudinal carina in the middle.

Life History.—The cactus scale is very prolific and often masses in such numbers as to entirely hide the host. As it usually occurs in warm climates, there are probably several broods a year.

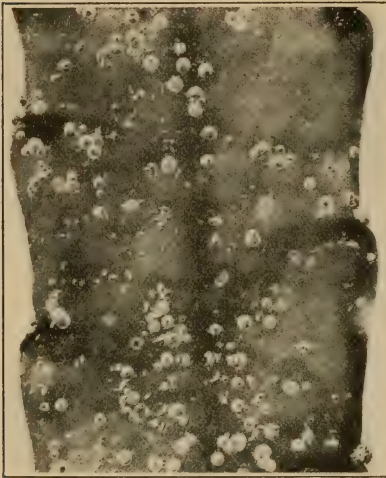


Fig. 145.—The cactus scale, *Diaspis echinocacti* Comst., on *Opuntia*. Natural size. Collected at Ventura by S. H. Essig. (Original)

Nature of Work.— This species works upon the joints of cactus, causing considerable loss of sap and in not a few cases entirely killing the plant. It is especially troublesome in ornamental gardens, hothouses and artificial plantings.

Distribution.— The scale is common throughout the State in hothouses and quite widely distributed out of doors in the central and southern parts.

Food Plants.— Various species of *Opuntia* and *Cereus* are attacked.

Control.— Dipping the plants in kerosene or crude oil emulsion before setting out and spraying them with

these solutions or any of the oil emulsions are recommended.

THE ZAMIA SCALE

Diaspis zamiae Morgan

(Fig. 146)

Description.—The scales are nearly circular, light gray, with yellow or dark-brown exuviae near one side. The diameter varies considerably but averages about $\frac{1}{16}$ inch. The bodies of the females are yellow.

Life History.—The life history of this scale is practically the same as for the other species of the same genus.

Nature of Work.—This is a very prolific species which masses in great numbers upon the leaves and stems of the food plants. Injury is caused by constant sapping of the juices and is manifested by discolorations and the unhealthy appearance of the infested plants.

Distribution.—The zamia scale is commonly taken in quarantine and has become established in greenhouses around San Francisco Bay.

Food Plants.—Various species of *Zamia* and the sago palm are attacked.

Control.—The use of oil emulsion or miscible oil sprays and fumigation are suggested as control measures. Potted plants may be either dipped in the above solutions or fumigated in a tight compartment.

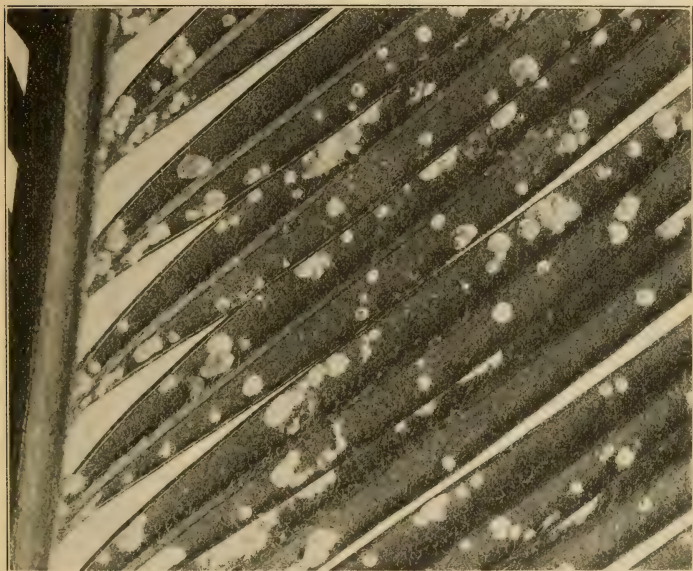


Fig. 146.—The zamia scale, *Diaspis zamiae* Morg., on sago palm. Enlarged three times. Collected at Golden Gate Park, San Francisco, by B. B. Whitney. (Original)

THE ROSE SCALE

Aulacaspis rosæ (Bouché)⁶³

(*Aspidiotus rosæ* Bouché)

(Fig. 147)

Description.—The female scales are nearly circular with irregular edges, white to light gray and with yellow exuviae near one edge. The diameter varies from $\frac{1}{12}$ to $\frac{1}{8}$ inch. The bodies are red. The male scales are white, narrow, very small, tricarinated, and are one half as long as the diameter of the females. The bodies are pink.

Life History.—All stages of this scale occur practically throughout the entire year, including the eggs, and its spread is very rapid. The females cluster in great numbers upon the canes of berries and roses, especially around the crown just above the ground. It is more abundant during the spring and summer months. There are three or more broods a year.

Nature of Work.—The scales collect in great numbers upon the stems or canes, especially near the ground. They often overlap and completely hide these, so that they appear whitewashed. The hosts are greatly weakened and injured by them.

Distribution.—This is a very common species throughout the entire State.

Food Plants.—Blackberry (wild and cultivated), dewberry, mango, myrtle, pear, raspberry, rose, sago palm and Tree of Heaven are attacked.

Control.—As the eggs are present at practically all seasons and are hard to kill, by either spraying or fumigation, the cost of the remedies usually exceeds the damage done by the insect. The worst infested canes may be cut out and burned and the remaining sprayed successively with kerosene, distillate or carbolic acid emulsion, or with lime-sulphur when the plants are dormant in the winter.

Natural Enemies.—Two minute hymenopterous parasites, *Aphelinus diaspidis* and *Arrhenophagus chionaspis*, attack the rose scale.



Fig. 147.—The rose scale, *Aulacaspis rosæ* (Bouché), on wild blackberry. Only slightly enlarged. (Original)

THE ASPIDISTRA SCALE

Hemichionaspis aspidistræ (Signoret)

(*Chionaspis aspidistræ* Signoret)

(Fig. 148)

Description.—The female scales slightly resemble the oyster-shell scale in shape, being rather long and broadly rounded at the posterior

⁶³Mr. Frederick Maskew has informed the writer that the West Indian or white peach scale, *Aulacaspis pentagona* (Targ.), was found in a single locality in southern California many years ago, but the infested trees were destroyed and the insect has not become established.

end. They are thin and delicate in texture and light or dark brown with exuviae somewhat brighter. The length varies from $\frac{1}{16}$ to 1-11 inch. The male scales are white, tricarinate, slender and with edges parallel.

Life History.—The young hatch from eggs deposited under the shell and appear throughout nearly the entire year, especially in greenhouses and in warm, moist climates. There are several overlapping broods a year. The scale is a general greenhouse pest in this State, but is quite destructive to coconut palms in the Society Islands.⁹⁴

Nature of Work.—This species attacks the leaves and stems, often massing in great numbers and doing considerable damage, causing the foliage to turn yellow and greatly reducing the vitality of the plant.

Distribution.

—The aspidistra

scale is very common throughout the State.

Food Plants.—Acacia, Australian blackwood, *Aspidistra*, betel nut, coconut, *Cyanotis*, *Davallia pallida*, ferns, fig, mango, orange, orchids and pepper trees are food plants.

Control.—Spraying the plants constantly with water when the eggs are hatching will eliminate many of the young. Applying a combination of oil emulsions or miscible oils and tobacco decoction will also give good results.



Fig. 148.—The *Aspidistra* scale, *Hemichionaspis aspidistræ* (Sign.), on *Aspidistra lurida*. Natural size. (Original)

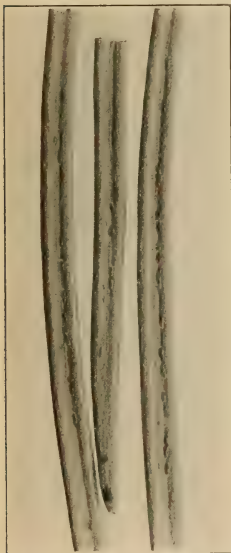


Fig. 149.—The European Fiorinia, *Fiorinia floriniæ* (Targ.), on sago palm. Natural size. (Original)

THE EUROPEAN FIORINIA

Fiorinia floriniæ (Targ.)

(*Diaspis floriniæ* Targ.)

(Fig. 149)

Description.—The female scales are elongated, slender with parallel sides or slightly wider in the middle, hard and yellowish brown. There is a central keel along the dorsum which is wrinkled. The length varies from 1-25 to $\frac{1}{16}$ inch. The bodies are elongated and dull orange-yellow. The male scales are similar to the females in shape and color but are smaller.

Life History.—This scale breeds quite rapidly in greenhouses and in damp warm climates. There appear to be several broods a year.

⁹⁴Doane, R. W., Jr. Ec. Ent., II, p. 220, 1909.

Nature of Work.—The leaves and stems are attacked but the scale has not proven to be a pest excepting in greenhouses.

Distribution.—The European Fiorinia is often taken in quarantine and occurs in greenhouses, parks and ornamental gardens in the State.

Food Plants.—*Anthurium acaule*, betel nut, camellia, coconut, cypress, English ivy, ferns, India rubber, *Kentia* sp., *Leptospermum*, *Livistona*, olive, ivory-nut palm, *Podocarpus*, sago palm and tea are food plants.

Control.—Control measures are the same as for the *Aspidistra* scale, *Hemichionaspis aspidistræ* (Sign.).

THE EUROPEAN OR ITALIAN PEAR SCALE

Epidiaspis piricola (Del Guercio)

(*Aspidiotus piricola* Del Guercio)

(Fig. 150)

Description.—The female scale is nearly circular or slightly elongated, glossy dark gray with a dark brown central exuvia. The body is dark wine-red or purplish, which readily distinguishes it from the scale insects usually found on fruit trees. The scale of the male is smaller than that of the female, long and narrow and pure white with a single median longitudinal carina and yellow exuvia. The length of the female scale is about $\frac{1}{16}$ inch and the male one half as much.

Life History.—The life history does not greatly differ from that of the scurfy scale, *Chionaspis furfura* (Fitch).

Distribution.—The distribution of this scale appears to be limited to the San Francisco Bay region, having been taken in Alameda, Solano, Santa Clara and Napa counties. It was recently taken on a shipment of mountain holly from Goleta, Santa Barbara County, by A. A. Brock at Ventura.

Food Plants.—The apple, currant, mountain holly, peach, pear, plum and prune are the known hosts of the European or Italian pear scale in California.

Control.—This scale can be controlled with practically the same remedies as are recommended for the San Jose scale. Mr. Paul R.



Fig. 150.—The Italian pear scale, *Epidiaspis piricola* (Del Guercio). The scales are located among the lichens on an apple twig. Enlarged twice. (Original)

Jones⁹⁵ has obtained good killing results with a 12 per cent solution of crude oil emulsion.

THE CALIFORNIA BUCKEYE SCALE

Aspidiotus æsculi Johnson

(Fig. 151)

Description.—The female scales are light gray, conforming well to the color of the bark. They are nearly circular, flat and $\frac{1}{16}$ inch in diameter. The exuviae are orange colored and central or nearly so. The bodies of the females are pale yellow. The male scales are the same color as the females, but are much smaller and decidedly elongated. The species is quite prolific and the scales may be so abundant as to overlap.



Nature of Work.—On the California buckeye, *Æsculus californicus*, the scales produce decidedly flattened areas and pits, which greatly disfigure the branches. This does not seem to occur on other hosts.

Distribution.—The species exists quite plentifully in the Santa Clara Valley. It has also been taken in Tulare County by G. P. Weldon and in Yolo County by Mr. Leroy Childs.

Food Plants.—The California buckeye appears to be the favorite host, but the scale has also been taken on poplar by G. P. Weldon, on bur-oak, linden and pear by others and on willow by Leroy Childs.

Control.—The control measures are the same as for the San Jose scale, *Aspidiotus perniciosus* Comst.

PUTNAM'S SCALE

Aspidiotus ancylus (Putnam)

(*Diaspis ancylus* Putnam)

Fig. 151.—The California buckeye scale, *Aspidiotus æsculi* Johns., on poplar. Enlarged twice. Collected at Porterville, Cal., by Geo. P. Weldon. (Original)

Description.—The female scale is slightly wider than long, or nearly circular, flat, blackish-brown with gray margin and pale yellow subcentral exuvia. The diameter is from 1-20 to $\frac{1}{12}$ inch. The body of the female is pale or orange-yellow marked with small light spots. The male scale greatly resembles the female but is smaller and more elongated, being 1-20 inch long and one half as wide.⁹⁶

⁹⁵Bul. No. 80, pt. VIII, Bur. Ent. U. S. Dept. Agric., 1910.

⁹⁶Comstock, J. H., Rept. Com. Agric. U. S. Dept. Agric., pp. 292, 293, 1880.

Distribution.—This species, though reported in the State,⁹⁷ is not at all widely distributed.

Food Plants.—The following plants are reported as hosts: apple, apricot, ash, beech, bladder nut, box-elder, cherry, cottonwood, cranberry, currant, elm, hackberry, hemlock, linden, honey-locust, water-locust, maple, oak, orange, osage orange, peach, pear, plum and quince.

Control.—Control measures are the same as for San Jose scale (*Aspidiotus perniciosus* Comst.).

THE LAUREL SCALE

Aspidiotus britannicus Newstead

(Fig. 152)

Description.—The scale is light amber-brown with yellow exuvia and is circular or somewhat elongated. The female scale averages about $\frac{1}{16}$ inch in diameter. The male scale is smaller. The body is yellow.

Life History.—The life history of this scale does not differ greatly from that of the pernicious or San Jose scale, except that its attacks seem to be confined almost entirely to the foliage.

Distribution.—This scale has been introduced from Europe and is likely to be found in ornamental plantings throughout the State. It now occurs in the San Francisco Bay region.

Food Plants.—The English laurel, holly and butcher's broom are attacked.

Control.—The control measures are the same as those recommended for the San Jose scale.

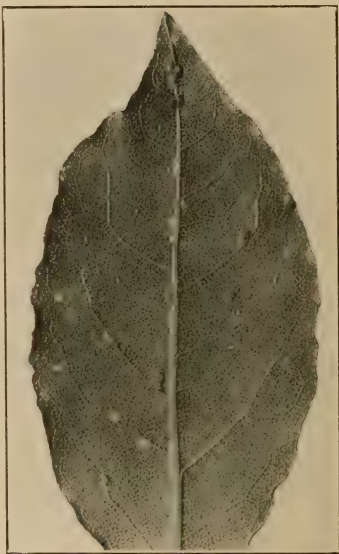


Fig. 152.—The laurel scale, *Aspidiotus britannicus* Newst., on leaf of English laurel or bay-tree. Slightly enlarged. (Original)

THE CALIFORNIA PINE-LEAF SCALE

Aspidiotus californicus Coleman⁹⁸

(Fig. 153)

Description.—The scale is nearly black in color and almost circular or elongated, as shown in Fig. 153. The scale of the female is about $\frac{1}{16}$ inch in diameter and the male somewhat smaller. The female body is yellowish or brown. The insects settle in large numbers on the needles of the pine trees.

⁹⁷Woodworth, C. W., Cal. Insects, p. 281, 1913.

⁹⁸This scale greatly resembles *Aspidiotus abietis* (Schr.), which is so common in the Eastern States, but which has not been reported in California.

Life History.—The life history of this scale greatly resembles that of the pernicious or San Jose scale, except that it is entirely a leaf and not a bark feeder.

Distribution.—This scale is very abundant in the central and northern parts of the State.

Food Plants.—The following pine trees are attacked: digger pine, Monterey pine, yellow pine and knob-cone pine.

Control.—If necessary, use same remedies as recommended for the San Jose scale.

THE GREEDY SCALE

Aspidiotus camelliae Signoret

(*Aspidiotus rapax* Comstock)

(Fig. 154)

Description. — The scale is thin, light gray, very convex, being noticeably pointed with the dark brown exuvia subcentral or near the edge. The surface is often roughened by fine concentric ridges. The diameter is 1-20 inch. The female body is oblong or nearly circular and yellow. The male scale is not as convex as the female, is more elongated and very much smaller.

Life History.—The life history is practically the same as that of the San Jose scale.

Nature of Work.—Though this scale is often abundant upon the limbs and leaves, it seldom does much damage. However, growth is sometimes stunted where infestation covers a long period of time.

Distribution.—The greedy scale is one of the most common scale insects and occurs throughout the entire State.

Food Plants.—This species is an omnivorous feeder, attacking a large number of plants, including acacia, almond, apple, buck brush (*Ceanothus cuneatus*), camellia, camphor, chapparal broom (*Baccharis pilularis*), cherry, *Cissus*, cottonwood, English ivy, *Eucalyptus*, *Euonymus*, fig, fuchsia, *Genista*, grape, heath (*Erica*), mountain holly, honeylocust, Japanese quince, California laurel, *Lavatera*, locust, mistletoe, myrtle, nightshade, olive, palms, passion vine, pear, pepper tree, *Pittosporum*, pomegranate, quince, red-bud, sage, rose, *Sedum*, *Streptocarpus*, umbrella tree, English walnut, willow and yam (*Dioscorea*).

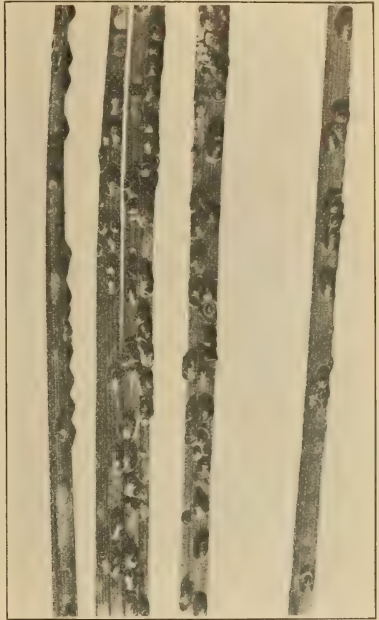


Fig. 153.—The California pine-leaf scale, *Aspidiotus californicus* Colm., on the needles of yellow pine. Enlarged twice. (Original)

Control.—It is seldom, if ever, necessary to use control measures for this scale, but should it prove to be a pest the remedies are the same as recommended for the San Jose scale.

Natural Enemies.—The internal hymenopterous parasite, *Aphelinus fuscipennis* How. has been reared in great numbers from this species.

THE IVY OR OLEANDER SCALE

Aspidiotus hederae (Vallot)
(*Chermes hederae* Vallot)

(Fig. 155)

Description.—The female scales are flat, nearly circular, light gray and from 1-20 to $\frac{1}{12}$ inch in diameter. The exuviae are light yellow and central or sub-central. The bodies are oval and light yellow. The male scales are light gray, elongated and 1-25 inch long. When feeding upon the fruit of lemons this species often assumes a pinkish color and may be mistaken for the red scale (*Chrysomphalus aurantii*), but the light color of the scales, the yellow exuviae and the flat surface make it easily distinguished from the latter.

Life History.—The life history is practically the same as that of the San Jose scale.

Nature of Work.—This species attacks all parts of the host. It is a greenhouse pest and often causes alarm to citrus growers by appearing on the fruit, but it seems to attack only old "tree ripes" and is of little consequence in this connection. Until recently it was thought to be a pest in the olive orchards of the Sacramento Valley, attacking fruits, making them unfit for pickling purposes.⁹⁹

Distribution.—The ivy scale is abundant throughout the State and country.

Food Plants.—Acacia, aloe, asparagus ferns, betel nut, boxwood, buckthorn, butcher's broom, California laurel, camellia, carob, *Carmo-*



Fig. 154.—The greedy scale, *Aspidiotus camellia* Sign., on acacia. Enlarged twice. Collected at Ventura by S. H. Essig. (Original)

⁹⁹It has been recently discovered by Mr. Geo. Coleman that the scale usually found attacking the fruit of the olive in the Sacramento Valley is not the ivy or oleander scale, but a closely allied species known as *Aspidiotus similimus translucens* Ckll. This scale greatly resembles the ivy or oleander scale in general appearance and can only be distinguished from it by an expert. Besides the olive it also attacks tea, *Loranthus* and *Dalbergia championii*.

The cyanophyllum scale, *Aspidiotus cyanophylli* Signoret has been recently taken on grape from the vicinity of Sacramento. It also attacks *Cinchona*, *Cyanophyllum*, *Ficus*, laurel, moonflower, orchids, palms and sago palm. The specimens were determined by Geo. A. Coleman.

detus serratus, cherry, citron, clover, currant, *Daphne gnidium*, date palms (*Phoenix dactylifera* and *P. canariensis*), eucalyptus, fan palm (*Latania borbonica*), ferns, *Genista*, grapefruit, grass, heath, holly, English ivy, *Kentia*, lemon, madder, magnolia, manzanita, maple,



Fig. 155.—The ivy or oleander scale, *Aspidiotus hederae* (Vall.). Greatly enlarged. (After Quayle, Cal. Agrcl. Exp. Sta.)

mistletoe, Monterey pine, mulberry, *Myrsine retusa*, nightshade, oleander, olive,⁹⁹ *Opuntia littoralis*, orange, pepper tree, plum, pomegranate, holly oak (*Quercus ilex*), red-bud, redwood, sago palm, sumach, umbrella plant, umbrella tree, *Vitex littoralis*, *Vriesia splendens* and yucca are hosts.

Control.—Control measures are the same as for San Jose scale.

Natural Enemies.—Ladybird beetles and a small undetermined chalcid parasite prey upon this scale.

THE WALNUT SCALE

Aspidiotus juglans-regiae Comstock

(Fig. 156)

Description.—The female scales are light gray, nearly circular, with yellow, pink or reddish-brown central or subcentral exuviae. The diameter varies from $\frac{1}{10}$ to $\frac{1}{8}$ inch. The bodies are yellow mottled with orange spots, oval and distinctly segmented. The male scales are the same color as the females, more elongated and about one third as large.

Life History.—The life history is practically the same as for the San Jose scale.

Nature of Work.—All forms settle upon the trunks, large branches and small twigs of the host plants. The adults often appear to mine into the bark and may be completely hidden from view. Large limbs or entire trees may be killed by their attacks, which greatly resemble those of the San Jose scale.

Distribution.—This scale appears to be quite widely distributed throughout the southern part of the State. It has become quite a pest to walnut trees in Orange County.

Food Plants.—Apple, apricot, white ash, prickly ash, box-elder, cherry, cottonwood, currant, elm, linden, locust, maple, peach, pear, plum (domestic), plum (wild), prune, rose, sweet gum and English walnut are hosts of the walnut scale.¹⁰⁰

Control.—The remedies are the same as for San Jose scale.

Natural Enemies.—The following internal hymenopterous parasites have been reared from the English walnut scale: the golden chalcid (*Aphelinus diaspidis* How.), *Encyrtus ensifer*, *Prospaltella aurantii* How. and *Signiphora occidentalis* How.



Fig. 156.—The walnut scale, *Aspidiotus juglans-regia* Comst., on English walnut. Enlarged twice. Collected at Anaheim by Roy K. Bishop. (Original)

THE EUROPEAN FRUIT-TREE SCALE

Aspidiotus ostryaformis Curtis

Description.—The scales of the full-grown females are nearly circular, dark ashy-gray with the exuvia dark orange-colored and sub-central. The diameter is about $\frac{1}{12}$ inch. The male scales differ only in being somewhat smaller and more elongated.

Life History.—The life history of this scale is not materially different from that of the San Jose scale.

¹⁰⁰Yearbook, U. S. Dept. Agric., pp. 300-301, 1880.

Nature of Work.—All stages feed upon the bark and in a few cases have killed the trees.

Distribution.—The distribution of this scale in California is not well known. It does not seem to have made any considerable headway in the State.

Food Plants.—Like many other members of the genus *Aspidiotus*, this coccid is a general feeder attacking alder, apple, apricot, aspen, birch, cherry, currant, date palm, hawthorn, heather, horse-chestnut, linden, maple, oak, peach, pear, plum, prune and poplar.

Control.—Control measures as recommended for the San Jose scale may be used in combatting this pest also.

Natural Enemies.—The two-stabbed (*Chilocorus bivulnerus* Muls.) and other ladybird beetles feed upon all stages of the European fruit-tree scale.

THE PERNICIOUS OR SAN JOSE SCALE

Aspidiotus perniciosus Comstock

(Figs. 157, 158)

Description.—The female scales are nearly circular, slightly convex, quite dark when young, light gray when fully matured and from 1.25 to $\frac{1}{12}$ inch in diameter. The exuviae are central or nearly so and form yellow or dark nipples. The bodies are oval and light yellow. The male scales are much smaller than those of the female, twice as long, as wide and very dark gray or black. The adult males are pink and exceedingly small and delicate.

Life History.—The winter is spent in a half-grown condition, when the scales of the females are black. Maturity is reached in spring and early summer, the young being born at this time. They settle upon the leaves, fruit, limbs and trunks of the trees where they may be massed in great numbers. There are from one to three uneven broods a year.

Nature of Work.—This species attacks the trunk, large and small limbs, leaves and fruit, producing a very characteristic red or purple stain which discolours the tissues. On the fruit and just beneath the bark the discolorations are very noticeable (Fig. 158). Limbs and entire trees are often killed by the attacks and fruit is rendered worthless for market because of the reddish blotches produced upon the skin.

Distribution.—The San Jose scale is a very common pest, occurring throughout the entire State and country.

Food Plants.—Acacia, *Actinidia*, *Akebia*, alder, almond, flowering almond, apple, crab apple, apricot, arborvitae, ash, American mountain ash, European mountain ash, beech, birch, false bittersweet, blackberry, buttonbush, buckthorn, catalpa, *Ceanothus*, cherry, sand cherry, chestnut, black chokeberry, chokecherry, *Cercidiphyllum japonicum*, cotton-easter, currant, dogwood, elder, elm, eucalyptus, *Euonymus*, fig, gooseberry, grape, hackberry, hawthorn, *Hibiscus*, honeysuckle, hop-tree,

horse-chestnut, English huckleberry, lilac, linden, locust, honey-locust, loquat, maple, milkweed, mulberry, orange, osage orange, trifoliate orange, peach, pear, sand pear, pecan, persimmon, *Photinia villosa*, plum, poplar, California privet, common privet, prune, quince, Japanese or flowering quince, raspberry, rose, sassafras, shad-bush, silver thorn, smoke bush, snowball, snowberry, *Spiræa*, sour gum (*Nyssa*), strawberry, sumach, Virginia creeper, English walnut, black walnut and willow are among the food plants.

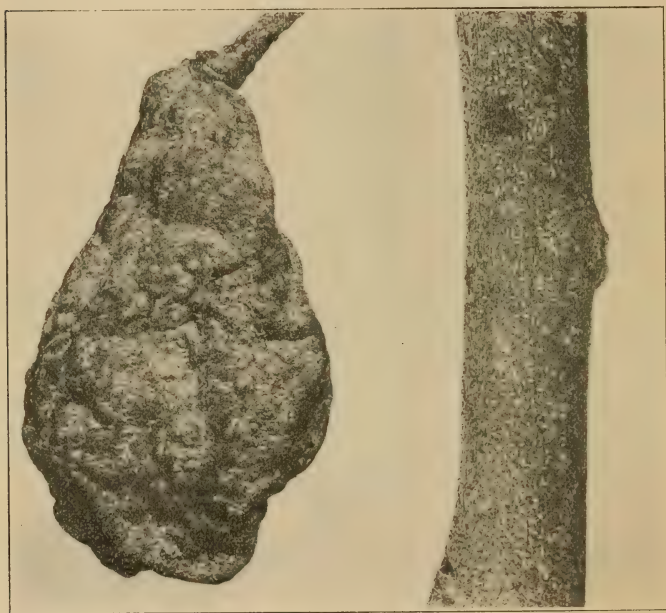


Fig. 157.—The pernicious or San Jose scale, *Aspidiotus perniciosus* Comst., on pear and willow. The pear was taken in Imperial County by F. W. Waite. Natural size. (Original)

Control.—The application of commercial lime-sulphur spray (1 to 9 or 1 to 11 of water) during the dormant season in the winter, as a driving spray has given good results. Care should be taken to thoroughly cover every portion of the tree.

Natural Enemies—The internal hymenopterous parasites, *Aphelinus fuscipennis* How., *A. mytilaspidis* LeB., *Aspidiotiphagus citrinus* Craw., *Anaphes gracilis* How.,¹⁰¹ and the two-stabbed ladybird beetle

¹⁰¹Yearbook, U. S. Dept. Agric. p. 254, 1894.

(*Chilocorus bivulnerus*), *Lindorus lopanthus* Blaisd. and the steel-blue ladybird beetle (*Orcus chalybeus* (Boisd.) prey upon the San Jose scale.

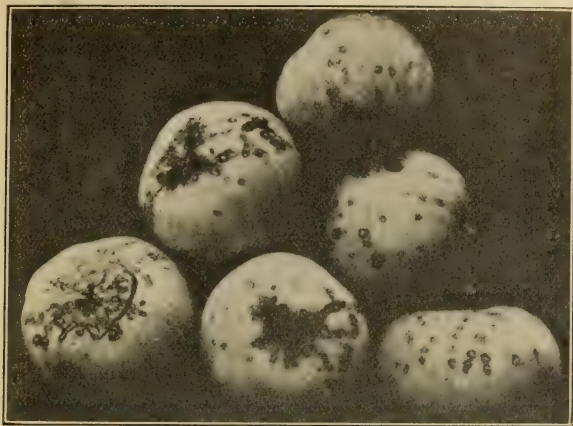


Fig. 158.—The pernicious or San Jose scale, *Aspidiotus perniciosus* Comst. Infested apples showing the characteristic reddish blotches around the scales. Reduced. (After Britton)

THE FLORIDA RED SCALE

Chrysomphalus aonidum (Linnæus)

(*Chrysomphalus ficus* Ashmead)

(*Coccus aonidum* Linnæus)

(Fig. 159)

Description.—The scales are characterized by their exceedingly regular and circular form, shining dark brown surface and median circular exuvie. They are slightly larger, more regular and darker than those of the common red or orange scale. (*Chrysomphalus aurantii*).

Life History.—The life history is practically the same as that of the red scale (*Chrysomphalus aurantii*).

Nature of Work.—This species collects in large colonies upon the branches and leaves of the host plants, causing them to turn yellow or even killing them.

Distribution.—Though the Florida red scale is troublesome in the Southern Gulf States, as an outdoor pest, its attacks in California are almost entirely confined to greenhouses in the central and northern parts and to subtropical ornamental gardens in the southern part of the State. It is not an orchard pest.

Food Plants.—*Araucaria bidwillii*, *Aspidistra lurida*, banana, begonia, camellia, camphor, citron, coconut, grapefruit, guava, India

rubber, *Kentia* spp., lemon, oleander, orange, fan palm, date palm, rose and sago palm are attacked.

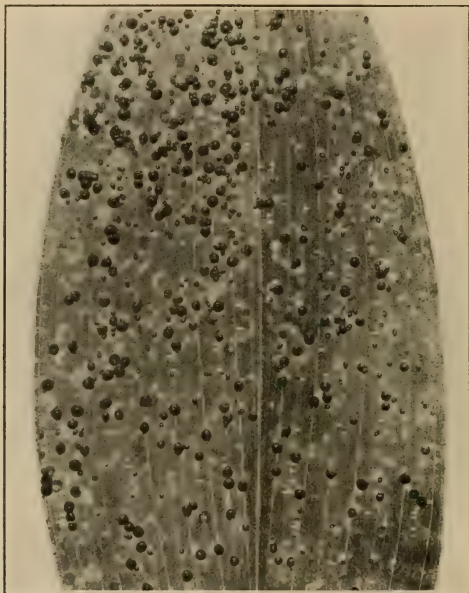


Fig. 159.—The Florida red scale, *Chrysomphalus aonidum* (Linn.), on *Aspidistra lurida*. Natural size. (Original.)

Control.—Control measures, if necessary, are the same as for the red scale.

THE RED SCALE

Chrysomphalus aurantii (Maskell)¹⁰²
(*Aspidiotus aurantii* Maskell)

(Fig. 160)

Description.—The scales are distinctly circular and flat, those of the female varying from $\frac{1}{16}$ to $\frac{1}{8}$ inch in diameter. They are transparent, allowing the red female body, which gives it the distinctive color, to show through. The male scales are elongated, very much smaller and gray or dark brown in color.

Life History.—The winter is spent in a half-grown condition and the young are born alive during the summer (June to September). The species is exceedingly prolific and destructive.

Nature of Work.—All parts of the tree including trunk, large and small limbs, leaves and fruit are attacked. Yellow spots appear upon

¹⁰²Now considered *Aonidiella aurantii* (Maskell) by some specialists.

the foliage, and the fruit is rendered unfit for market. Large limbs and entire trees may even be killed by their attacks.

Distribution.—The red scale occurs throughout the southern citrus belt, and is particularly bad in sections of San Diego, Orange, Los Angeles, Riverside, San Bernardino and Santa Barbara counties.

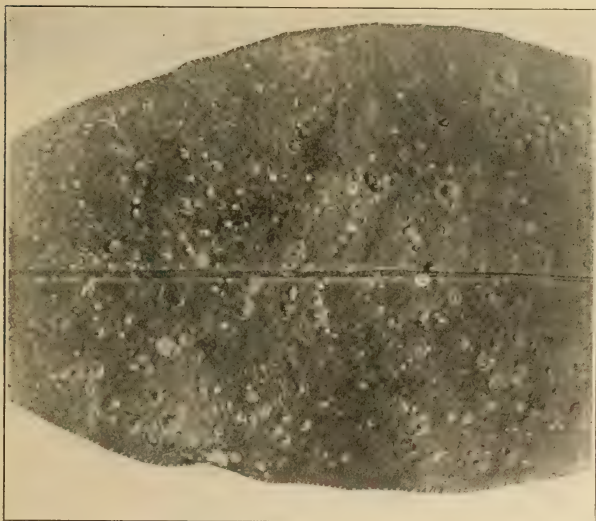
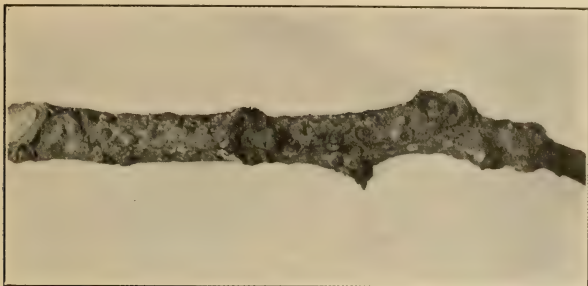


Fig. 166.—The red scale, *Chrysomphalus aurantii* Mask., on twig and leaf of orange. Enlarged twice. (Original)

Food Plants.—Acacia, aloe, apple, bread-fruit (*Artocarpus*), box-elder, boxwood, citron, coconut, eucalyptus, *Euonymus*, fig, fuchsia, golden rod, grape, grapefruit, *Kennedy*, lemon, *Lignum vitae*, bur-marigold, nightshade, oak, olive, orange, trifoliate orange, palm, Cali-

fornia fan palm, date palm, passion vine, pear, pistacia, *Podocarpus*, privet, quince, rose, sago palm, tangerine, tea, English walnut and willow are attacked.

Control.—Fumigation with full schedule No. 1 is specially recommended. Spraying is only efficacious on deciduous fruit trees with lime-sulphur (1 to 9), miscible oil sprays, crude oil or distillate emulsion.

Natural Enemies.—The ladybird beetles, *Orcus chalybeus* Bois., *Lindorus lophanthus* Blaisd., *Chilocorus bivulnerus* Mul., *Scymnus marginicollis* Mann., *Scymnus nebulosus* Lec., *Hippodamia convergens* Guer., *Hippodamia ambigua* Lec., *Coccinella californica* Mann., the green lacewing (*Chrysopa californica* Coq.), the brown lacewing (*Symphorobius angustus* Bks.); some of the members of the hemipterous family *Reduviidæ*; the internal parasites, *Prospaltella aurantii* How., *Coccophagus lunulatus* How., *Aspidiotiphagus citrinus* Craw., *Signiphora occidentalis* How., *Aphycus immaculatus* How., *Alaptus criococci* Girault and *Phycus flaviventris* How., all prey upon this pest.

THE YELLOW SCALE

Chrysomphalus citrinus (Coquillett)¹⁰³
(*Aspidiotus citrinus* Coquillett)

(Fig. 161)

Description.—The scales are circular with rather rough and irregular edges, very flat and decidedly yellow in color. The color and feeding habits serve to distinguish it from the red scale.

Life History.—The life history is practically the same as that of the red scale, the chief difference being in the feeding habits: the red scale usually attacks the trunks, small limbs, leaves and fruit, while the yellow scale attacks all but the trunks and small limbs. Some county commissioners consider this more serious than red scale on citrus trees. While this may be true in some sections, yet as a general citrus pest it does not seem to be as serious as red scale is in some of the southern coast counties.

Nature of Work.—This species attacks the leaves and fruit and very seldom one or two individuals may be found upon the tenderest twigs. Yellow blotches are produced upon the leaves and the trees may

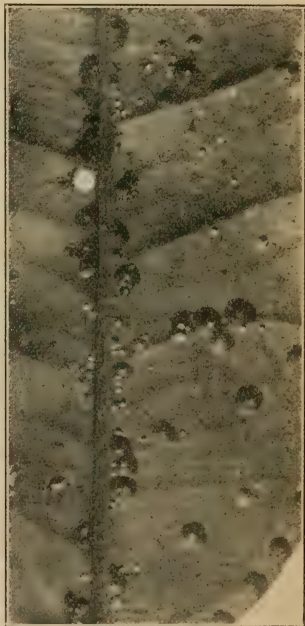


Fig. 161.—The yellow scale, *Chrysomphalus citrinus* (Coq.), on orange leaf. Enlarged twice. (Original)

¹⁰³This species is usually considered as a climatic variety of the red scale, *Chrysomphalus aurantii* (Mask.), from which it is not structurally distinguishable.

be greatly weakened and the foliage turned yellow by their attacks. The infested fruit is unfit for market.

Distribution.—This species is widely distributed throughout the entire citrus growing sections of the State, being especially abundant in the hotter interior valleys. It is abundant in the northern citrus belt.

Food Plants.—*Aucuba*, citron, *Daphne*, *Euonymus*, wild Japanese ginger, grapefruit, India rubber, English ivy, lemon and orange are attacked.

Control.—Control measures are the same as for the red scale.

Natural Enemies.—The predaceous insects are the same as those working upon red scale. *Aspidiotiphagus citrinus* Craw is the most effective internal parasite.

THE BLACK ARAUCARIA SCALE

Chrysomphalus rossi (Maskell)

(*Aspidiotus rossi* Maskell)

(Fig. 162)

Description.—The scale of the adult female is circular or irregularly oblong with ragged margins, flattened, reddish to dark brown or almost black with inner surface around and including the central exuvia black. The male scale is smaller and lighter in color. The female body is reddish-yellow and about $\frac{1}{16}$ inch long. The eggs are light purple and hatch soon after being laid. The young larvæ are pink.

Nature of Work.—This scale works upon the stems and leaves of the plants, causing yellow blotches and often complete discoloration to the entire foliage.

Distribution.—The black araucaria scale was imported from Australia or Asia and is now established in the southern part of the State, having been taken in Los Angeles County by A. S. Hoyt and in Santa Barbara County by S. H. Essig.

Food Plants.—The only host reported in California is *Araucaria bidwillii*. W. W. Froggatt¹⁰⁴ records the following food plants in Australia: *Araucaria imbricata*, *Abutilon*, *Artemisia*, *Banksia*, *Coccobolus*, *Copparis*, *Euonymus*, grasstree, hyssop, oleander, olive, palm and *Rhinocarpus*.

Control.—Control measures are the same as for red scale.

Natural Enemy.—The steel-blue ladybird beetle, *Oreus chalybeus*, preys upon this scale.



Fig. 162.—The black araucaria scale, *Chrysomphalus rossi* (Mask.), on *Araucaria bidwillii*. Natural size. Taken in quarantine from Santa Barbara County by S. H. Essig. (Original)

¹⁰⁴ Agrcl. Gaz. N. S. W., p. 317, Apr. 2, 1914.

THE GLOOMY SCALE

Chrysomphalus tenebricosus (Comstock)

(*Aspidiotus tenebricosus* Comstock)

Description.—The scales of the adult females are circular, very convex and dark gray being usually the color of the infested bark. The surface is rough and the exuviae subcentral. The ventral scale is well developed, dark around margins and light at the center. The diameter of the scale is 1-19 inch. The female bodies are nearly circular and amber-brown. The scales of the males are the same color as the females but much smaller, oval, and with the exuviae at one end.

Distribution.—This scale was reported by Alexander Craw as injuring apple trees at San Jose, Santa Clara County, in 1891,¹⁰⁵ but has not been reported from other localities or from the same locality in recent years.

Food Plants.—The only host plants recorded are apple and maple.

Control.—The control measures are the same as recommended for San Jose scale.

THE PURPLE SCALE

Lepidosaphes beckii (Newman)

(*Coccus beckii* Newman)

(Fig. 163)

Description.—The female scales are elongated, oyster-shaped, often slightly curved, from $\frac{1}{10}$ to $\frac{1}{4}$ inch long and one third as wide. The color varies from light brown to a rich reddish-purple. The male scales are much smaller than the females, very narrow and with a hinge near the posterior end to allow the matured winged male to escape. The length of the male scale is about $\frac{1}{16}$ inch. The mature male is light yellow and exceedingly minute. The eggs are slightly oblong, very small and pearly white.

Life History.—The eggs are deposited in the large egg-sac composed of the female scale. These hatch in early summer (May to July) and the young reach maturity in from four to six months. The species is very prolific, there being several overlapping generations a year.

Nature of Work.—This scale is a very serious pest and attacks all portions of the host, including trunks, large and small limbs, leaves and fruit. It may become so abundant as to hide the twigs and not rarely to kill entire trees, unless control measures are employed.

Distribution.—The purple scale is distributed throughout the coast citrus belt of southern California, but is not present in a large number of districts in this region. It also occurs in various places in the San Joaquin and Sacramento valleys.

Food Plants.—*Banksia integrifolia*, *Cercidiphyllum japonicum*, citron, croton, eucalyptus, fig, grapefruit, lemon, *Murraya exotica*, oak, olive, orange, *Pomaderris apetala*, silver thorn, hop-tree and yew (*Taxus cuspidata*) are among the recorded food plants.

Control.—This scale is very resistant to fumigation and a full dosage of schedule No. 1 is required to control it. Small infestations have

¹⁰⁵Destr. Ins., Cal. Bd. Hort., p. 11, 1891.



Fig. 168.—The purple scale, *Lepidosaphes beckii* (Newman), on orange leaves. Left, much enlarged; right, slightly enlarged. The small slender scales are those of the males. (Original)

been practically exterminated where two of these dosages were used in succession at an interval of one hour and repeated in a year. The time usually chosen for fumigation is from the middle of August to the first of January, when the black scale can be killed also.

Natural Enemies.—The ladybird beetles, *Orcus chalybeus*, *Scymnus marginicollis*, *Lindorus lophanthus*; the larvæ of the green lacewing, *Chrysopa californica* Coq., and brown lacewing, *Symphorobius angustus* Bks., and the internal parasite, *Aspidiotiphagus citrinus* Craw, prey upon this pest, though they are of slight value in checking its ravages.

GLOVER'S SCALE

Lepidosaphes gloverii (Packard)
(*Coccus gloverii* Packard)

(Fig. 164)

Description.—The scales of this species greatly resemble those of the purple scale, but are lighter in color, very much narrower and not so curved. The female scales are about $\frac{1}{12}$ inch long and the males about one half as long. The color varies from light to dark brown. The eggs are slightly oblong, very small and pearly white.

Life History.—The life history is practically the same as for the purple scale, but this species is not nearly so prolific or destructive in California.

Nature of Work.—Glover's scale infests all parts of the host plant, causing discoloration of the foliage, but in this State it has not yet proven to be an orchard pest.

Distribution.—This scale occurs only in the most southern coast counties. The writer has received it from San Diego and Orange counties.

Food Plants.—Citron, grapefruit, lemon, *Magnolia fuscata*, orange and palms are attacked.

Control.—Control methods are the same as for the purple scale.



Fig. 164.—Glover's scale, *Lepidosaphes gloverii* (Pack.), on orange leaf. Slightly enlarged. (Original)

THE OYSTER-SHELL SCALE

Lepidosaphes ulmi (Linnæus)
(*Coccus ulmi* Linnæus)

(Fig. 165)

Description.—The female scales appear like miniature oyster shells from whence the species gets the common name. They vary from light to very dark brown, the young and overwintering forms being often

decidedly gray. The surface is shiny and ridged with lines parallel to the first exuvia. The body proper is situated at the small end. The length of the scale varies from $\frac{1}{10}$ to $\frac{1}{8}$ inch. The male scales are similar to the females in color, but are much smaller and have a hinge near the posterior end. The males are small, delicate two-winged insects. The eggs are oval and pearly white.

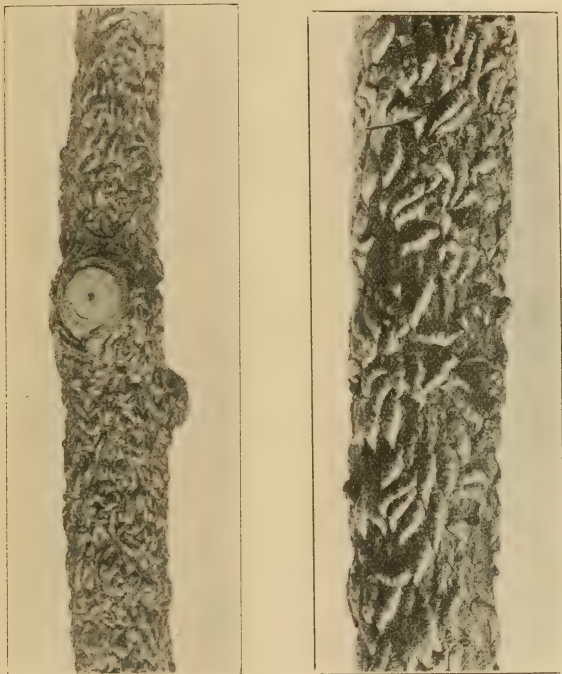


Fig. 165.—The oyster-shell scale, *Lepidosaphes ulmi* (Linn.). Natural size and enlarged. On maple. (Original)

Life History.—The females deposit from forty to a hundred eggs beneath the scale in the fall. These remain over the winter and hatch in May and June. The young first settle upon the leaves, fruit and tender twigs and afterwards move to the older bark. The species is quite prolific and the scales are often so thick as to completely hide the bark. There is usually but one uneven brood a year.

Nature of Work.—The trunks, large and small limbs, leaves and fruit are attacked, but the species is principally a bark feeder. Limbs or entire trees may be killed by their attacks.

Distribution.—This species is common throughout the State.

Food Plants.¹⁰⁶ — Alder, almond, American aspen, false indigo (*Amorpha*), apple, crab apple, apricot, arrow-wood, ash, balm of Gilead, basswood, beech, bilberry, white birch, river birch, bittersweet, blackthorn, bladder nut, boxwood, box-elder, broom, buckeye, buckthorn, butternut, camellia, camphor, cherry, chestnut, *Clematis paniculata*, coconut, cotoneaster, cranberry, black currant, red currant, dogwood, elm, water elm, false bittersweet, fig, filbert, fir (*Abies firma*), ginseng, gooseberry, goat's-beard, grape, hackberry, hawthorn, heath, heather, holly, honeysuckle, hop-tree, horse-chestnut, *Horena dulcis*, June-berry, leather leaf, leather-wood, lilac, lime, linden, locust, water locust, maple, mespil, American mountain ash, European mountain ash, mountain holly, myrtle, nectarine, New Jersey tea, oak, orchid, *Pachysandra terminalis*, peach, pear, peony, pepper grass, plum, poplar, quince, raspberry, rock-rose, rose, sassafras, senna, silver thorn, *Spiraea*, sycamore, tallow tree, tamarisk, tree of Heaven, tulip-tree, *Magnolia tripitala*, *Viburnum*, Virginia creeper, willow, English walnut and yucca are among the plants attacked.

Control.—As this species usually occurs on deciduous trees, spraying with lime-sulphur (1 to 11) just before the buds open in the spring

has given very good results. A kerosene or crude oil emulsion applied in the winter is also effective. Commercial control is seldom necessary in this State.

Natural Enemies.—The following internal hymenopterous parasites have been reared from the oyster-shell scale:¹⁰⁷ the golden chalcid (*Aphelinus diaspidis* How.), *A. fuscipennis* How., *A. mylitaspidis* LeB., *A. abnormis* How., *Aspidiotiphagus citrinus* Craw, *Anaphes gracilis* How. and *Cheiloneurus diaspidinarum* How. Ladybird beetles also prey upon it to a large extent.

THE THREAD SCALE

Ischnaspis longirostris (Signoret)
(Mytilaspis longirostris Signoret)
(Ischnaspis filiformis Douglas)

(Fig. 166)

Description.—The common name well characterizes this scale, which is exceedingly long and slender. The scales of the adults are black, straight or curved and from $\frac{1}{12}$ to $\frac{1}{8}$ inch long. Fig. 166 shows them very well.



Fig. 166.—The thread scale, *Ischnaspis longirostris* (Sign.). Natural size. On palm. (Original)

from $\frac{1}{12}$ to $\frac{1}{8}$ inch long. Fig. 166 shows them very well.

¹⁰⁶Cir. No. 121, Bur. Ent. U. S. Dept. Agric., pp. 5-6, 1910.

¹⁰⁷Yearbook, U. S. Dept. Agric., p. 254, 1894.

Cir. No. 121, Bur. Ent. U. S. Dept. Agric., p. 6, 1910.

Life History.—Little is known relative to the life history of the thread scale, but it is probably similar to that of the oyster-shell scale or the purple scale.

Nature of Work.—The species usually feeds upon the foliage, where it often collects in large numbers.

Distribution.—The insect occurs in the San Francisco Bay region and in greenhouses throughout the State.

Food Plants.—Coffee, jasmine, magnolia, *Monstera*, palmetto, fan palm, palms and screw pine are common hosts.

Control.—Resin wash, miscible oils and oil emulsions may be used to control this scale. Young infested plants should be dipped if possible.

THE DATE PALM SCALE

Parlatoria blanchardii (Targ.)¹⁰⁸

(*Coccus blanchardii* Targ.)

(Fig. 167)

Description.—The female scales are very small, somewhat elongated in shape and dark gray or almost black with white edges. The length is about 1-18 inch. The body beneath the scale is rose-colored. The male scales are white and considerably smaller than the females.

Life History.—Like other scales, this species collects in great colonies, and often works much damage to the host plant. The colonies are most destructive during the summer months, as the females are more or less dormant during the winter. Egg-laying begins early in the spring and continues through the early summer at least. Only a few eggs are laid by each female, but there are so many of the latter that the progeny is always tremendous. The eggs are protected under the posterior portion of the scale and as they hatch the young crawl forth to seek suitable feeding places. The males develop much quicker than do the females, and copulate immediately before dying. There are probably several uneven generations a year.

Nature of Work.—The scale collects in great numbers upon the stems and leaves of the date palms and their attacks are often so severe as to kill the trees. The young offshoots become infested almost as soon as they appear and are a ready means of distributing the pest.



Fig. 167.—The date palm scale, *Parlatoria blanchardii* (Targ.), on palm leaf. Enlarged twice. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

¹⁰⁸In Dr. G. Leonardi's work this name is spelled *Parlatoria blanchardi* (Targ.).

Distribution.—As this pest is confined to the date growing sections of the State, it is found only in the southern part, and more particularly in Riverside and Imperial counties.

Food Plant.—So far as known, this scale feeds only upon the commercial varieties of the date palm.

Control.—Removing all of the branches and burning over the entire trunks of the palm trees with a gasoline torch has proven, according to Professor R. H. Forbes,¹⁰⁹ to be an effective remedy for this scale. The remedies given under the Marlatt scale, *Phanicoccus marlatti* Ckll. are also used for this insect.

Natural Enemies.—The principal enemies of this pest are the larvæ of the ashy-gray ladybird beetle (*Olla abdominalis*), *Chilocorus cacti* and *Scymnus* sp. Internal parasites do very little to check it; in fact, none of the natural enemies play an important part in its control.



Fig. 168.—The chaff scale, *Parlatoria pergandii* Comst., on orange leaf. Enlarged twice. (Original)

THE CHAFF SCALE

Parlatoria pergandii Comstock¹¹⁰

(Figs. 168, 169)

Description.—The female scales are small, irregular, nearly circular or slightly elongated, dirty-gray in color, with the exuviae near one end. The male scales are decidedly longer than broad, light gray with the lateral margins prominent.

Life History.—This is quite a prolific species, which has not gained any considerable foothold in California. Breeding continues throughout the year in the southern part, there being several broods annually.

Nature of Work.—The scale collects in great numbers upon the trunks, large and small limbs, leaves and fruit of the trees and greatly reduces the vitality and causes the leaves to turn yellow and drop.

Distribution.—This species is limited to only a few localities in the State. It was first shown to the writer by C. H. Vary at Pomona and was later found at Ventura. A. S. Hoyt reports it from

¹⁰⁹Jr. Ec. Ent., VI, pp. 415-416, 1913.

¹¹⁰A variety, *Parlatoria pergandii camelliae* Comst., has been taken on camellia at Sacramento. Fig. 169.

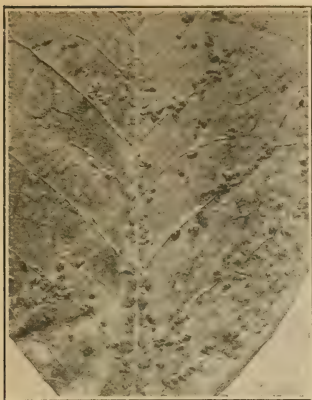


Fig. 169.—*Parlatoria pergandii camelliae* Comst., on camellia leaf. Enlarged twice. (Original)

posterior end. In the male scales very small, while in the females it is elongated and slightly over 1-25 inch long. They are massed together in dense colonies and are easily recognized at once by the black color.

Distribution. — This scale does not at present occur in California. It is a common serious citrus pest in the Philippine Islands, southern Europe, Hawaii and many other tropical and subtropical countries, and is often taken in quarantine. Strict measures should be maintained against its becoming established here.

Food Plants. — The citron, grapefruit, lemon, lime, orange and *Zizyphus* are attacked.

Control. — Control measures are the same as for the chaff scale.

¹¹¹Another common *Parlatoria* (*Parlatoria proteus* Curtis) is also often taken in quarantine. It is light-gray in color and also a citrus pest, but not as serious as the above.

Los Angeles. It has also been taken in a few other localities in the southern part of the State, having been imported from Florida.

Food Plants. — Citron, croton, grapefruit, *Japonica*, lemon, *Maranta*, *Massangea* and orange are attacked.

Control. — Fumigation with full schedule No. 1 gives good killing results, as it is not a very difficult pest to combat.

THE BLACK PARLATORIA¹¹¹

Parlatoria zizyphus (Lucas)

(*Coccus zizyphus* Lucas)

(Fig. 170)

Description. — The scales of the males and females are distinctly black with a colorless portion at the posterior end. In the male scales the black area is nearly circular and



Fig. 170.—The black *Parlatoria*, *Parlatoria zizyphus* Lucas, on orange leaf. Enlarged three times. Collected in the Philippine Islands by Harry S. Smith. (Original)

ALEYRODIDÆ (Family)

MEALY WINGS OR WHITE FLIES

This family is composed of very small insects closely allied to the coccids and plant lice. The beak seems to be inserted between the fore-legs; the feet are two-segmented; the antennæ, when present, are seven-articled in adults. There are four opaque, white wings which are present in the mature males and females and are held flat over the body when at rest. The larvæ and nymphs are flat and greatly resemble scale insects. They are usually found only upon the foliage, the under sides of the leaves being favorite feeding places.

The distribution of the ordinary and non-destructive members of this family is wide throughout the State, but the citrus infesting white fly is exceedingly limited and every possible means are being exercised by the State Commission of Horticulture to completely eradicate *Dialeurodes citri* (R. & H.), the only species now present.

The control of the white flies is the same as recommended for scale insects and consists of spraying and fumigation.

Ladybird beetles and hymenopterous parasites prey quite extensively upon these insects.

THE CITRUS WHITE FLY

Dialeurodes citri (Riley and Howard)

(*Aleyrodes citri* Riley and Howard)

(Figs. 171, 172)

Description.—The adult white flies are about $\frac{1}{16}$ inch long and have yellow bodies and opaque wings covered with a fine white powder. The males have a characteristic tuft on the under side of the abdomen. The pale yellowish-green eggs are suspended on short stalks. The first hatched young have legs and antennæ like a small scale insect, but after molting these disappear and the body becomes flat, greatly resembling a soft scale. The development of the insect takes place under the flattened scale, which gradually becomes raised, showing segmentation and yellowish color. The adults emerge by breaking through the top of the skin.

Life History.—The winter is passed in the mature larval stage, usually on the under sides of the leaves. Early in the spring the pupæ appear and in March and April the adults emerge. The eggs are deposited upon the foliage, the larvæ beginning to hatch in about three weeks. The first hatched young have legs and other appendages, much as do young scale insects. They soon settle to feed and after a

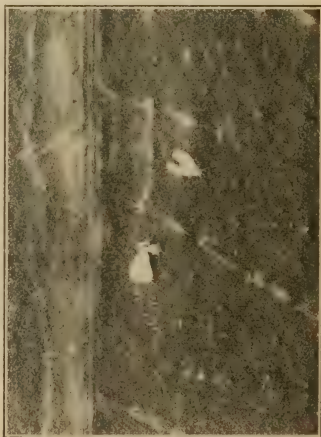


Fig. 171.—The citrus white fly, *Dialeurodes citri* (R. & H.). Adults enlarged six times. (Original)

short time move no more until the adult stage is reached. There are several overlapping broods each year.

Nature of Work.—The immature forms alone are destructive and feed almost entirely upon the under sides of the leaves and are often so thick as to completely cover the surface. Besides sucking the sap they secrete quantities of honey-dew upon which the black smut fungus grows, completely covering the tree and fruit.



Fig. 172.—The citrus white fly, *Dialeurodes citri* (R. & H.). Larvæ and nymphs on orange leaf. Enlarged six times. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

Distribution.—At the present time this pest is known to exist only in the city of Marysville, where it infests yard trees. Continuous control measures have reduced it to almost a minimum. The white fly has been known to exist at Oroville and near Bakersfield,¹¹² but in both places seems to have been exterminated. It has been found in a number of localities in the city of Sacramento, but all infested trees have been completely destroyed.

¹¹²The white fly at Bakersfield was another species, *Dialeurodes citrifolii* (Morgan), previously known as *Aleyrodes nubifera* Berger.

Food Plants.—The known host plants of the citrus white fly are: allamanda, banana shrub, Boston ivy, cape jasmine (*Gardenia florida* and *G. jasminoides*), California privet, laurel cherry, citron, crape myrtle, coffee, English ivy, *Ficus macrophylla*, golden privet, green ash, Japanese persimmon, *Jasminum fruticans*, kumquat, laurestinus, lemon, lilac, pear, orange, Mexican orange, mock olive, myrtle, osage orange, Portugal cherry, pomegranate, prickly ash, smilax, tangerine, tree of Heaven, trumpet vine, umbrella tree, water oak, wild persimmon, wild olive or devilwood and yellow cape jasmine.

Control.—By far the most effectual control measure is fumigation, as used for scale insects, two-thirds of schedule No. 1 being recommended. Emulsions and resin sprays are also effective remedies.

THE IRIS WHITE FLY

Alcyrodes spiræoides Quaintance

(Fig. 173)

Description.—The adults are light yellow with dark markings on head, thorax and the dorsum of the abdomen. The eyes are red and the antennæ and legs are dusky. The entire body and wings are covered with a very fine white powder which entirely hides all of the markings except two small dark spots on each fore wing and one on each hind wing. When the wings are folded they overlap so that there appears to be but one dark spot on each forewing. The length is nearly 1.25 inch. The eggs are very minute, oblong and attached at one end by a very short stipe. The color is first lemon yellow but becomes almost dark purple before hatching. The young larvæ are elliptical, light yellow with a white marginal fringe which gradually disappears as they grow older. Full-grown larvæ are light yellow or dusky, flat, naked or slightly covered with white powder. The eye spots show red. The length averages about $\frac{1}{8}$ inch. The pupæ are broadly elliptical, light yellow or dusky, sparsely covered with white powder, convex, much higher than the larvæ and somewhat longer.

Life History.—The life history is practically the same as for the greenhouse white fly.

Nature of Work.—The young feed upon the foliage and are often so abundant as to stunt the plants and cause the foliage to turn yellow besides the smutting because of the honey-dew.

Distribution.^{113, 114}—This species has quite a wide distribution, having been reported from the following counties: Alameda, Los Angeles, Santa Clara, San Francisco and Santa Cruz.

Food Plants.—The following food plants are recorded by Quaintance¹¹³ and Bemis¹¹⁴: *Agoseris* sp., black twinberry, buckeye, dahlia, fuchsia, iris, malva (*M. rotundifolia*), morning-glory (*Convolvulus occidentalis*), nightshade (*S. douglasii*), nine bark, plantain, Cherokee rose, common sow thistle and tree tobacco.

It has become a very serious pest of the common iris in Berkeley and Oakland during the past years and is also common on sow thistle.

¹¹³Quaintance, A. L., Tech. Ser. No. 8, Bur. Ent. U. S. Dept. Agric., p. 38, 1900.

¹¹⁴Bemis, Florence E., Proc. U. S. Nat. Mus., XXVII, p. 532, 1904.

Control.—Control measures are same as for the greenhouse white fly and are very unsatisfactory, even when the entire tops are cut and burned, as reinfestation occurs as soon as the new growth appears.

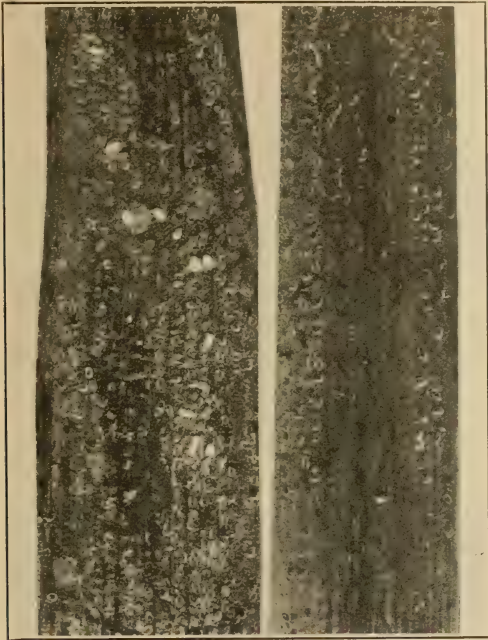


Fig. 173.—The iris white fly, *Aleyrodes spiræoides* Quaint. Eggs, larvæ, nymphs and adults on iris. Enlarged twice. (Original)

THE GREENHOUSE WHITE FLY

Asterochiton vaporariorum (Westwood)
(*Aleyrodes vaporariorum* Westwood)

(Fig. 174)

Description.—The adult female white flies are about $\frac{1}{16}$ inch long, the males being slightly smaller. The bodies are yellow and the wings pure white. The eggs are exceedingly small, oblong in shape, at first light green, growing black with age and attached by a short stipe. The larvæ are light in color, transforming to flat nymphs about 3-100 inch long, oblong-oval in shape, light green and supporting noticeable wax-like rods or spines, which makes this species readily distinguishable from all others.

Life History.—The eggs are laid upon the leaves of the plants, each female depositing over one hundred. These hatch in about two weeks

into larvæ which begin feeding very shortly and after three moults, covering nearly a week, become nymphs, and after two weeks more the adults emerge from the pupal skins. They feed constantly throughout their existence of some thirty days as mature insects.

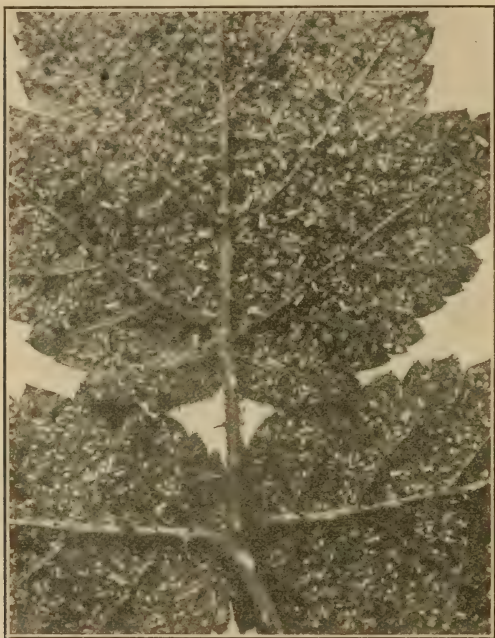


Fig. 174.—The greenhouse white fly, *Asterochiton vaporariorum* West. Larvæ, nymphs and adults on the underside of a wild blackberry leaf. Enlarged three times. (Original)

Distribution.—This species occurs in greenhouses in almost every part of the State. Due to the mild climate it also occurs in the open in many sections, especially in the central and southern parts.

Food Plants.—Of the cultivated plants, tomatoes and cucumbers seem to suffer most from the attacks of this pest, though a larger number of other plants are attacked, including *Ageratum*, aster, bean, begonia, chrysanthemum, coleus, eggplant, fuchsia, geranium, grape, Jerusalem cherry, *Lantana*, lettuce, muskmelon, pepper, primrose, rose, sage, blackberry, strawberry and watermelon.

Control.—Nicotine and soap sprays as recommended for plant lice should be used in dealing with this pest, especially upon tender plants. (See pages 71 and 72.)

HETEROPTERA (Suborder)

TRUE BUGS

The members of this suborder comprise those insects commonly known as bugs. Most of them have wings which are thickened at the base and folded so as to make a distinct "X" upon the back. The young appear much like the adults, but lack wings, developed sexual organs and are very much smaller.

Though most of them are destructive to vegetation, many are carnivorous and wage continual warfare against injurious insects and other animals.

In habits there is also a great variance, both aquatic and land forms being represented.

Many are known as "stink bugs," because of the peculiar and offensive odor which is secreted for protective purposes.

PENTATOMIDÆ (Family)

SHIELD BUGS

The members of this family are usually of medium size, somewhat shield-shaped, flat and because they emit a very pungent odor are also called "stink bugs." The antennæ are five-jointed, which gives rise to the family name. The tibiæ have very few or no spines. In habits they vary greatly, some are plant feeders and therefore injurious, while others are carnivorous and may be classed as beneficial.

THE RED-SHOULDERED PLANT-BUG

Thyanta custator (Fabricius)

(Fig. 175)

Description.—The full-grown bugs vary from yellowish-green to bright green or brownish-green, with distinct red shoulders and often with a broad red band across the prothorax between the shoulders. The tip of the scutellum and the margins of the front wings are also sometimes lined with red. The membranous parts of the wings are colorless, and when folded form a light area on the posterior dorsum. The average length is about $\frac{3}{8}$ inch and the width across the base of the prothorax $\frac{1}{4}$ inch. When disturbed they emit a very offensive odor.



Fig. 175.—The red-shouldered plant-bug, *Thyanta custator* (Fab.). Adults enlarged three times. (Original)

The young hatch early in summer and mature within a month. There appears to be but one uneven brood a year.

Nature of Work.—These bugs pierce and suck the juices of the host plants, and, where large numbers congregate, they may cause a decided

Life History.—The adults hibernate in sheltered places and appear on the plants in scattering numbers in the spring, when egg-laying begins. The

weakening of the plant. They often emit a very offensive odor on berries, making them unfit for consumption.

Distribution.—This species is a very common one and is generally distributed throughout the State.

Food Plants.—There is a large range of food plants, including alfalfa, berries, flowers, fruit trees, grasses and weeds.

Control.—Though this bug is very common, it seldom congregates in any great numbers and control measures have never been necessary.

Natural Enemies.—A hymenopterous parasite, *Trissolcus thyanæ* Ashm.¹¹⁵ destroys many of the eggs.

THE HARLEQUIN CABBAGE BUG

Murgantia histrionica Hahn

(Figs. 176, 177)

Description.—The adult bugs are black with bright red markings, as shown in Fig. 177. They are $\frac{1}{2}$ inch long and two thirds as wide. The eggs are almost imitations of miniature white barrels with black hoops and black spots in the proper places for bungholes. They are arranged in clusters side by side. The young greatly resemble the adults, but lack wings and yellow predominates. This color gradually changes to orange and red as the nymphs reach maturity.

Life History.—The adults hibernate in various sheltered places and appear with the first warm weather in the spring to feed. The first plants to furnish food are wild mustard, radish and other of the cruciferous weeds. Upon these also the eggs are laid, and the young soon appear in great numbers in time to migrate to the cabbage plants and work on them throughout the summer. Successive broods may appear in the cabbage fields and the numbers so increase as to cause much damage. In the southern part of the State the adults



Fig. 176.—Eggs of the harlequin cabbage bug, *Murgantia histrionica* Hahn. Enlarged four times. (Original)

continue active throughout the winter.

¹¹⁵Insect Life, IV, p. 124, 1891,

Nature of Work.—The bug in all stages pierces the tissues of the plant with the proboscis and sucks out the juices, thereby greatly weakening the host and causing the foliage to turn yellow. Plants are often dwarfed or entirely killed by its attacks.

Distribution.—This is a common insect throughout the entire State, but is more often met with in the central and southern sections.

Food Plants.—This bug is specially fond of all cruciferous plants, including cabbage, cauliflower, kale, radish, horseradish, rape, *Streptanthus orbiculatus* and mustard. Other food plants are asparagus, bean, beet, cherry, chrysanthemum, corn, eggplant, grape, lambsquarters, lemon, wild lettuce, locust, okra, orange, pigweed, plum, potato, ragweed, rose, squash and sunflower.

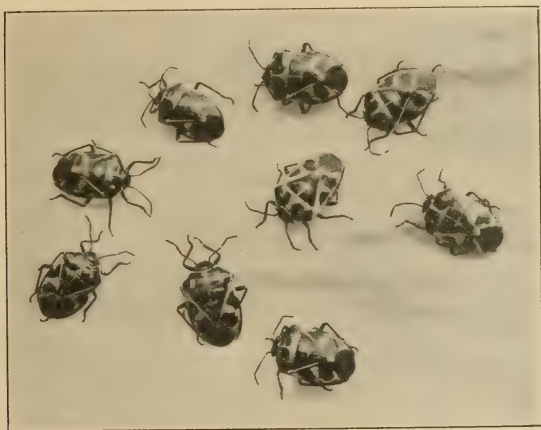


Fig. 177.—Adults of the harlequin cabbage bug, *Murgantia histrionica* Hahn. Natural size. (Original)

Control.—Methods recommended for the squash bug are also applicable to the control of the cabbage bug. Planting an early crop of cabbage, kale, rape, mustard or radish is especially recommended. The eggs are laid in great numbers upon these plants and together with the adults may be destroyed. This practice greatly lessens subsequent attacks.

Natural Enemies.—Great numbers of the eggs are destroyed by two small internal parasites, *Trissolcus murgantiae* Ashm. and *Oancyrthus johnsoni* How. The wheel bug, *Arilus cristatus* Linn., feeds upon the young nymphs in the Eastern States.

COREIDÆ (Family)

SQUASH BUGS

The species are usually of medium or rather large size, oblong in shape and flattened on the dorsum. The hind legs are sometimes abnormally enlarged and the margins of the abdomen are often raised

so that the folded wings lie in a depression. The beak is four-jointed and the feet three-jointed. The antennæ are inserted above a line drawn from the eyes to the base of the beak. The membranes of the wings have many forked veins rising from a transverse basal vein. The members are plant feeders and some often become quite destructive to crops.

THE SQUASH BUG

Anasa tristis DeGeer¹¹⁰

(Figs. 178, 179)

Description.—The small, somewhat three-sided eggs are dark metallic brown in color and laid in groups of from fifteen to forty. The newly hatched bug is light green with pinkish appendages. As it ages, the thorax, legs and antennæ become black and the abdomen gray. The adults are dark grayish-brown above, mottled yellowish beneath, and about $\frac{3}{4}$ inch long. They secrete a very offensive liquid, the odor of which has led to their being called "stink bugs." They hibernate in any dry protected place, under boards, rubbish, etc., or in barns or outhouses.

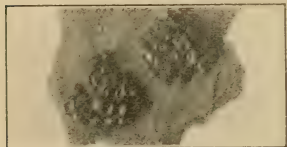


Fig. 178.—Eggs and nymphs of the squash bug, *Anasa tristis* DeGeer. Some of the eggs in the top picture have hatched. Natural size. (Original)

egg-laying as soon as the vines are suitable in the spring. There is only one generation each year.

Nature of Work.—The young and adults work upon the young plants, often entirely killing them. They also attack the young foliage of older plants. In the process of piercing the tissues, these bugs are carriers of fungous diseases, inoculating healthy plants from diseased ones.

Distribution.—The squash bug occurs throughout the State and is especially abundant in the central and southern parts.

Food Plants.—Most of the members of the squash family (*Cucurbitacæ*), including the pumpkin, squash and gourd are attacked by this bug.

Control.—Hand picking early in the spring, as soon as the adults appear and begin egg-laying is recommended. The vines are so tender

¹¹⁰The California species appears to be a varietal form of the Eastern species. Specimens examined by J. R. Torre de la Bueno and E. P. Van Duzee have led both experts to express this view.

that spraying is impracticable. The bugs may be trapped by placing in the garden, boards, pieces of bark or similar material under which they may find shelter. They may then be collected in the early mornings and destroyed. Young plants may be covered to afford protection until they are able to resist the attacks. Repellents, such as gypsum saturated with kerosene or turpentine, scattered on the land are said to help to drive them away. Clean culture is also suggested, care being taken to burn all vines and rubbish in the fall. Thoroughly fertilizing and watering the land may so stimulate plant growth as to make the attacks of the bug of little avail.



Fig. 179.—Adults of the squash bug, *Anasa tristis* DeGeer. Enlarged one and one fourth times. (Original)

Natural Enemies.¹¹⁷—In the Eastern States the egg parasites, *Hadronotus anasæ* Ashm. and *Ooencyrtus anasæ* Ashm. prey upon the squash bug. A tachinid fly, *Trichopoda pennipes* Fab. attacks the nymphs and adults, which are also subject to a bacterial disease, *Bacillus entomotoxicon* Dugger.

THE CACTUS-JOINT BUG

Chelinidea tabulata Burmeister¹¹⁸

(Fig. 180)

Description.—The color of the adult bugs varies from yellowish to reddish-brown, dark olive-green or nearly black, but the usual color is dusky-yellow with the antennæ, parts of the head, front and posterior margins of the prothorax, membrane of the wings and the legs dark brown or nearly black. The shape and general appearance are shown in Fig. 180. The length averages about $\frac{1}{2}$ inch. The eggs are elliptical, dark brown, mottled with whitish exudation, with finely punctured

¹¹⁷Cir. No. 39, Bur. Ent., U. S. Dept. Agric., p. 4, 1908.

¹¹⁸Mr. E. P. Van Duzee considers this species as probably a dark form of *Chelinidea vittiger* Uhler, which has been reported as attacking the *Opuntia* in the southern part of the State. Bul. No. 113, Bur. Ent. U. S. Dept. Agric., pp. 15-19, 1912.

surface and 1-20 inch long. They are deposited on the spines in rows of from twelve to fifty. The young are brownish or nearly black with light green or reddish abdomen.

Life History.—The adults hibernate under any shelter near the cactus plants and emerge to begin breeding early in the spring. The eggs are laid on the spines, each female laying from thirty to forty. The species feeds mostly at night in colonies on the joints of the cactus, producing light spots on the surface of the host. Breeding continues throughout the year, there being several overlapping generations.

Nature of Work.—The joints are the points of attack and the injury, at first appearing as small yellow spots, continues until the tissues become brown and deadened and the joints so weakened that the plants fall over. Some of these take new root, while many dry up and never recover. The whitish excrement of the bugs is always associated with the work and is a means of determining the cause of the damage.

Distribution.—This bug is widely distributed throughout the southern part of the State and the more arid regions of the southwestern portion of the United States.

Food Plants.—The various species of *Opuntia* are attacked and much damage is done to the plants. With the utilization of the spineless cactus as a forage plant the insect under discussion is likely to become better known.

Control.—Control measures which might be suggested for trial consist in destroying all possible rubbish under the plants to force the adults to seek hibernation elsewhere and the application of contact sprays (tobacco decoction and soap or oil emulsion) when the young appear in the spring of the year.



Fig. 180.—The cactus-joint bug, *Cheimideia tabulata* Burm. Adult and nymph. Enlarged twice. (Original)

THE BOX-ELDER PLANT-BUG

Leptocoris trivittatus (Say)

[*Serinetha trivittata* (Say)]

(*Lygaeus trivittatus* Say)

(Fig. 181)

Description.—The very young forms are bright red and when about half-grown they become marked with black. The adults are dull-black with red markings on the body and wings, as shown in Fig. 181. The average length of the females is nearly $\frac{1}{2}$ inch, and the width one third as much. The males are somewhat smaller.

Life History.—The adults hibernate in sheltered places and emerge early in the spring, as soon as the buds burst, to lay eggs which soon hatch into the small red young. These feed upon the foliage of the box-elder and mature within a couple of weeks. By the middle of

summer the mature bugs may become very abundant and congregate in large numbers. They often hang like bees upon tree trunks and in various places, causing much worry and alarm to those not familiar with their habits. During the winter they occasionally enter houses and are quite annoying.¹¹⁹



Fig. 181.—The box-elder plant-bug, *Leptocoris trivittatus* (Say). Adults slightly enlarged. (Original)

Nature of Work.—Foliage attacked by the box-elder plant-bug becomes yellowish and soon drops from the trees. Fruits from which the juice has been extracted dry up and either fall to the ground or fail to mature. The presence of the bug will always aid in discovering the source of such injuries.

Food Plants.—The normal food of this bug appears to be the foliage of the box-elder (*Negundo aceroides*), but it also feeds upon various other plants. During the summer the bug sometimes attacks fruit, often entailing much loss by sucking out the juices. Apples, grapes, peaches and plums have been thus injured.¹²⁰ Mr. Geo. P. Weldon found it feeding upon cherry trees in the Yucaipa Valley, San Bernardino County, May, 1914.

Distribution.—It occurs throughout the entire State and is very common in all of the Western States.

Control.—Only seldom does this bug become a pest and therefore hardly need receive more than occasional attention. The large numbers of bugs massed upon the tree trunks during sunny days in winter are easily collected and destroyed, thus greatly reducing spring broods. The young bugs are also readily killed with a soap, tobacco or oil emulsion spray.

¹¹⁹Insect Life VI, p. 328, 1894.

¹²⁰Insect Life, IV, p. 273, 1892

THE SPOTTED MILKWEED BUG¹²¹*Oncopeltus fasciatus* Dallas

(Fig. 182)

Description.—The mature bugs are rather long and slender, orange yellow or more often red with three large black marks on the dorsum, as shown in Fig. 182. The antennæ, legs, eyes and portions of head, thorax and abdomen are also black. The length varies from $\frac{1}{3}$ to $\frac{5}{8}$ inch. The eggs are elongated and light red in color. They are laid in loose masses. The young bugs are red with dark antennæ, eyes, legs and wing pads.



Fig. 182.—The spotted milkweed bug, *Oncopeltus fasciatus* Dall. Slightly enlarged. (Original)

Life History.—The adults hibernate under leaves, or in any sheltered place and often emerge and congregate in large numbers in sunny places during the winter. They have thus come to the attention of many fruit growers who have been not a little alarmed at the large colonies on the trunks of fruit trees and around the barns and houses. In the spring the females lay their eggs upon the young milkweeds and the newly hatched bugs feed only upon this plant. There are several generations a year.

Distribution.—This bug is very common throughout the entire State and country.

¹²¹Another common milkweed bug (*Lygaeus reclinatus* Say) is easily distinguished from the above by its smaller size and by the white spots on the membrane of the wings. The black markings on the dorsum are not arranged in three definite spots as in the above species.

Food Plants.—It feeds only upon the common milkweeds and is of no economic importance. It is included because of the great numbers of inquiries constantly received regarding its name and habits.

Control.—Control measures are not necessary for this apparently harmless bug.

LYGÆIDÆ (Family)

CHINCH BUGS

The members of this family are mostly quite small, narrow or oblong in shape, flattened above and of a rather soft texture. The beak is four-jointed and the feet three-jointed. The antennæ are inserted below a line drawn from the eye to the base of the beak. The wing membranes have four or five simple veins arising from their base; the two inner veins are sometimes joined, forming a cell near the base. All are plant feeders and many become very serious pests.

THE FALSE CHINCH BUG

Nysius erica Schilling
(*Nysius angustatus* Uhler)

Description.—The adults are very small grayish-brown bugs, about $\frac{1}{8}$ inch long. The young are somewhat lighter in color and have reddish-brown abdomens and lack wings. The legs and antennæ are quite long and are dark.

Life History.—The eggs are deposited in the spring and early summer by the hibernating adults, which appear at that time. The young are dull gray or brownish-red, and collect in great numbers upon the food plants. The life cycle is short, there being many successive broods each year.

Nature of Work.—The work is practically the same as that of the tarnished plant-bug.

Distribution.—This bug occurs throughout the entire State, being one of the commonest destructive insects.

Food Plants.—Many plants are seriously damaged, including alfalfa, apple, aster, cabbage, cauliflower, chrysanthemum, grape, grasses, lettuce, marguerite, mustard, potato, purslane, radish, spurge, strawberry, turnip and various other plants.

Control.—As this bug breeds largely upon wild plants, such as mustard, radish, purslane, etc., clean culture should be practiced to eliminate these food plants. Severe attacks to grapevines and young trees have resulted from allowing such weeds to grow in the orchards and vineyards.

Soap, emulsion and tobacco sprays are excellent remedies. Pyrethrum is also recommended, but is too expensive for large plantings.

THE MINUTE FALSE CHINCH BUG

Nysius erica minutus (Uhler)
(*Nysius angustatus minutus* Uhler)

Description.—The appearance of this insect is so much like the false chinch bug that it is commonly believed to be the same species.

In fact, it is the size that is the main difference, the minute variety being only about half as large ($\frac{1}{16}$ inch long).

Life History.—The life history is practically the same as that of the larger form, *Nysius ericæ* Schilling.

Nature of Work.—The work is the same as that of the tarnished plant-bug.

Distribution.—This species is especially abundant in the southern and central parts of the State, though it occurs in all other parts as well.

Food Plants.—The insect is especially destructive to sugar beets grown for seed. It works on grass and many wild plants and occasionally attacks lemon and orange trees after the cover crop has been plowed under. Such attacks are forced, due to the destruction of the native food plants. It has been collected in large numbers on cultivated flowers.

Control.—Control measures are the same as for the false chinch bug.

THE CHINCH BUG

Blissus leucopterus Say

Description.—The chinch bug is a very small black and white insect $\frac{1}{8}$ inch long. The eggs are about one third as long as the adults, oval and amber in color. The young vary from yellow and red to the color of the adults, depending upon the age.

Life History.—The winter is passed in protected places by the adult insects. The eggs are laid within the grass sheaths or upon the stems above or below the ground in the early spring, several hundred being laid by each female. They hatch in a very short time and the young begin work immediately, collecting in dense colonies and doing great damage. They moult four times before reaching maturity. There are two generations each year. The insects migrate very quickly when food becomes scarce in any locality.

Nature of Work.—This bug attacks growing grain, often so completely stunting the crop that it never matures. An infested field soon turns yellow and ceases to grow.

Distribution.—The chinch bug was first reported in the San Francisco Bay region as early as 1885.¹²² It has also been reported from the Sacramento and San Joaquin valleys and the southern part of Imperial County.¹²³ Though present in the State for many years it has not become a pest and is seldom if ever encountered.

Food Plants.—This insect feeds on barley, oat, wheat, grasses and corn. The destruction by it has been exceedingly great in the Middle States.

Control.¹²⁴—Where this bug has become a serious pest it is very difficult to control. Burning over the grass lands, the removal of all grass and weeds around fences, along roads and ditches, the destruction of corn stalks and the plowing under of stubble and all debris will serve to kill many of the hibernating adults.

¹²²Bul. No. 17, Bur. Ent. U. S. Dept. Agric., 1885.

¹²³Bul. No. 15, n. s. Bur. Ent. U. S. Dept. Agric., p. 11, 1898.

¹²⁴Sanderson, E. D., Insect Pests of Farm, Orchard and Garden, pp. 91-92, 1912.

When once established in a field of growing grain it is practically impossible to stop its ravages, but it may be partially kept from migrating to cornfields by making a dust furrow or a line of coal tar around the edges of the field, over which the insects are unable to pass. In the dust furrow the edge next to the field must be steep and covered with fine dust, which makes it impossible for the bugs to get a foothold in attempting to ascend the wall. Occasionally a deep hole should be sunk in the furrow, into which large numbers of the bugs will fall, or they may be killed in the furrows with a drag or an oil spray.

The application of an oil emulsion to infested corn is claimed to give some relief if the work is thoroughly done.

Natural Enemies.—A fungous disease attacks the chinch bug during wet weather, and while it does great execution it is not an important controlling factor.

THE DARK TRIPHLEPS¹²⁵

Triphleps tristicolor White (Family Anthicoridæ)

(Fig. 183)

Description.—This is a very small species, the adults averaging only about $\frac{1}{16}$ inch in length. The color is jet black with the exception of the bases and tips of the wings, which are white. When the wings are folded there appear to be three triangular white spots on the dorsum. The antennæ and portions of the legs are also very light in color.

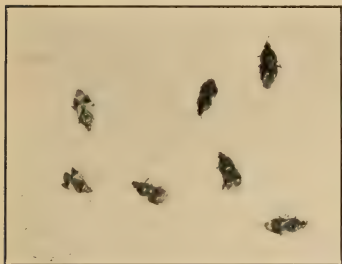


Fig. 183.—The dark Triphleps, *Triphleps tristicolor* White. Adults enlarged four times. (Original)

injuriously to plants, but there are as yet no such records of the California species.

Nature of Work.—The beak is exceedingly sharp and is used to pierce the prey and extract the juices from the bodies.

Distribution.—This species is widely distributed throughout the State.

Hosts.—The writer has collected the adults from plants infested with thrips, plant lice and mites upon which they appear to feed. Of the plant lice and thrips only the smaller ones become prey, while practically all stages of the mites are attacked.

¹²⁵This species generally replaces the insidious plant-bug, *Triphleps insidiosus* Say, which does not appear to occur in this State.

REDUVIIDÆ (Family)

KISSING BUGS, PIRATE BUGS OR ASSASSIN BUGS

(Figs. 184-186)

As the common names imply, these bugs are predaceous in habits. They feed upon many kinds of soft-bodied insects and other animals and vary greatly in size, but are mostly medium or quite large. The legs are long, the front pair often enlarged for grasping the prey. The head is very small and the antennæ three-



Fig. 184.—The rapacious soldier-bug, *Sinea diadema* (Say). The adults are light buff with darker brown markings. Female enlarged three times. (Original)



Fig. 185.—The western blood-sucking cone-nose, *Triatoma protractus* (Uhler). This is also known as the China bed-bug and sacred bug. It sometimes "bites" humans. The adults are dull black throughout and three fourths inch long. (Original)

jointed. The beak is short, stout, usually curved, three-jointed and very sharp. Because of their predaceous habits they are considered beneficial. Occasionally, however, people are bitten, but the bite is little more severe than the sting of a wasp or honey bee.

THE WESTERN CORSAIR

Rasahus thoracicus Stal

(Fig. 186)

Description.—The adults are striking in their appearance, being rather slender with long legs and antennæ and of a uniform yellowish-brown color. The length averages nearly $\frac{3}{4}$ inch. The membrane of the wings is black with a circular yellowish-brown spot in the middle of each. When the wings are folded these spots overlap and only the upper one appears like a single spot on the dorsum of the abdomen, just behind the middle. This species is one of the "kissing bugs" and lives up to that name at every afforded opportunity.

Life History.—The egg-laying habits of the adults and the younger stages are not known. The adults appear in the early spring and continue in evidence until winter. They are usually found singly and

are exceedingly active, feeding upon various soft-bodied insects. When captured they make a peculiar squeaking noise and are likely to insert the sharp proboscis into the flesh of the captor unless care is taken to prevent it. Occasionally they are found in beds or may crawl into clothing and will nearly always bite in self-defense.



Fig. 186.—The western corsair, *Rasahus thoracicus* Stal. Adult female, enlarged twice. (Original)

Distribution.—The above species is common in California and other Western States. It replaces the two-spotted corsair (*Rasahus biguttatus* Say) of the Middle and Eastern States, according to Mr. E. P. Van Duzee.

Food.—All stages of the bugs are predaceous upon other insects and apparently feed indiscriminately on such as come in their way. In general they are to be considered beneficial, rather than injurious, as they never attack plants and only occasionally bite people.

CAPSIDÆ (Family)

LEAF-BUGS, FLOWER-BUGS OR PLANT-BUGS

These are usually rather small, elongated or oval bugs of soft texture. The beak is four-jointed. The wing membranes have one or two closed cells at the base with no longitudinal veins. They are very active and among the most common of insects. Nearly all feed upon the tissues of plants and become serious pests, while a few are carnivorous, feeding upon plant lice and other small insects.

THE TARNISHED PLANT-BUG

Lygus pratensis Linnaeus

(Fig. 187)

Description.—The mature bugs vary from pale green to grayish-brown, marked with yellow, black and sometimes red. The legs are pale brown or yellow with dark rings. They average $\frac{1}{4}$ inch in length. The young bugs are lighter in color than the adults, without wings or pronounced markings. All forms are exceedingly common and very active.

Life History.—The winter is passed in the adult stage, activity and feeding continuing throughout the entire year in California. In the early spring the females insert the eggs into the stems and leaves, partially or entirely beneath the epidermis, by means of an ovipositor. In the leaves the eggs are usually inserted into the midribs or partially imbedded in the epidermis between the veins. In the stems they are buried into the tissues so as to be flush with the surface and not to

cause a swelling as on the leaves. The young begin to feed as soon as hatched, and, because of their great numbers, are able to do considerable damage. The species is very prolific and active and feeds upon a large variety of plants. There are several generations a year.

Nature of Work.—Like other bugs, this insect pierces the tissues with its beak or proboscis and extracts the juices, causing the plants to turn yellow and greatly retarding growth, if not stopping it altogether. It is not generally a pest except in dry years, or when its attacks are confined to a limited range of food plants. Apples are sometimes punctured in the process of egg-laying, causing dimples to appear on the fruit.¹²⁶

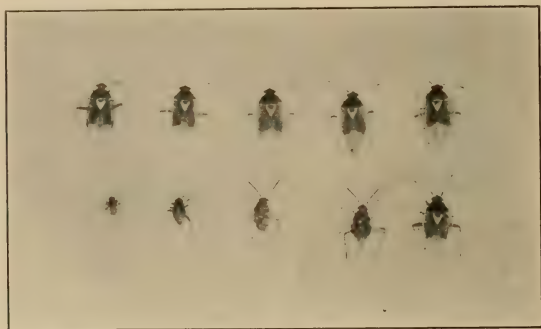


Fig. 187.—The tarnished plant-bug, *Lygus pratensis* Linn. Various stages in the development of the insect. Enlarged twice. (Original)

Distribution.—This is one of our most common insects and occurs in great numbers throughout the entire State.

Food Plants.—This bug feeds on a great many plants. It is especially abundant in grain or hay fields and attacks alfalfa, barley, clover, oats, rye, wheat, etc. All vegetable gardens afford a ready supply of food. It is often destructive to apple, pear and other fruit trees.

Control.—Because of its omnivorous habits and wide distribution, the tarnished plant-bug seldom becomes a serious pest of any one crop. For the same reasons, control measures are usually unnecessary. The presence of the insect need cause no alarm unless it is concentrating its attacks to a damaging degree on a few cultivated crops. In such cases contact insecticides, as oil emulsions, soap washes, tobacco sprays, resin washes, etc., may be used with deadly effect. These insecticides should be applied early in the morning and great care taken that they are not strong enough to injure the foliage of tender plants.

¹²⁶Jr. Ec. Ent. I, p. 370, 1908.

THE BLACK PLANT-BUG

Irbisia brachycerus Uhler

(Fig. 188)

Description.—The adults are rather slender, dark metallic bronze or black in color with light brown legs. The antennae are as long or are nearly as long as the body. The females are about $\frac{1}{4}$ inch long and the males only slightly smaller.

Life History.—The breeding habits of this species are yet unknown, but the young are evidently reared in the grasses and grainfields, maturing in May and June. At this time they often do great damage to various crops. All nourishment is obtained by sucking the juices from the hosts. The winter is passed in the adult stage.

Nature of Work.—The leaves of grasses and grains attacked by this bug first show numerous yellow spots, as shown in Fig. 188. Soon the whole leaves turn yellow and die. Other plants behave in the same manner and in many cases the discoloration of the tissues is accompanied by a curling of the leaves.

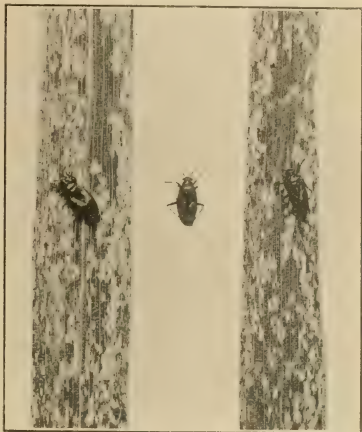


Fig. 188.—The black plant-bug, *Irbisia brachycerus* Uhler. Adults and their work on wheat. Slightly enlarged. (Original)

Distribution.—The black plant-bug is common throughout the State and has been observed as injurious in a number of localities.¹²⁷

Food Plants.—Grass, various weeds, lupines and many other plants are native hosts of this insect. It also occasionally attacks such cultivated plants as barley, cucumber, lettuce, oats, onion, peach, potato, radish, rhubarb and wheat.

Control.—In grainfields control measures are difficult, as the bug feeds quite near the ground. If the growth is not too large a hopper-dozer might be used with good results. In truck gardens the application of a repellent, as hellebore or possibly Bordeaux mixture, may give good results. The measures as recommended for the tarnished plant-bug are also applicable for this insect. In all probability, however, the injuries seldom warrant control measures.

THE LESSER BLACK PLANT-BUG

Irbisia sciriana Stål

(Fig. 189)

Description.—This bug greatly resembles the black plant-bug (*Irbisia brachycerus* Uhler), to which it is closely related, in color

¹²⁷Vosler, E. J., Mo. Bul. Cal. Hort. Com., II, pp. 551-553, 1913.

and general appearance, but is much smaller and has proportionately shorter antennae, which are only about two thirds the length of the body. The length of the females is about $\frac{3}{16}$ inch long, the males being somewhat smaller.

Life History.—The life history appears to be practically the same as that of the larger species (*Irbisia brachycerus* Uhler).

Nature of Work.—The work consists in making yellow spots on the foliage, which may later turn entirely yellow and die. Fig. 189 shows this work very well.

Distribution.—This species occurs in the State north of the Tehachapi and was especially abundant in the Santa Clara Valley in May, 1914.

Food Plants.—Grass and weeds are native hosts, but barley, oats and wheat are also at times severely injured, as was observed in 1914 by Leroy Childs. He also noted the following food plants: *Amsinckia intermedia*, man root, malva, mustard, thistle and sow-thistle.

Control.—Control measures are the same as for the black plant-bug and the tarnished plant-bug.

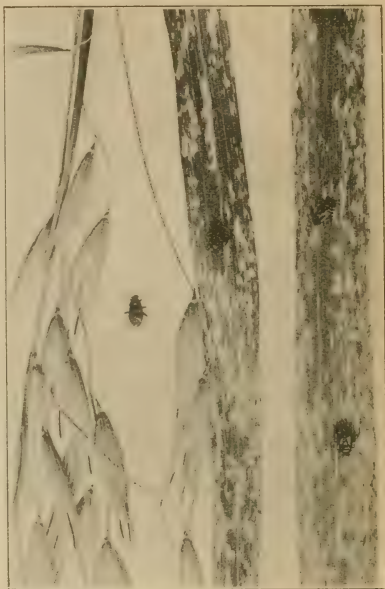


Fig. 189.—The lesser black plant-bug, *Irbisia sericans* Stal. Adults and work on oats. Natural size. Specimens taken at Stanford University by Leroy Childs. (Original)

THE PACIFIC PLANT-BUG

Thyrillus pacificus Uhler
 [*Tripsia pacificus* (Uhler)]
 (Fig. 190)

Description.—The mature bug is grayish-black throughout with somewhat clouded membrane at the tips of the wings. The head is the narrowest part of the body, which gradually widens nearly to the tip of the abdomen, where it is bluntly rounded, as shown in Fig. 190. The antennæ are slender and as long as the body, which averages $\frac{5}{16}$ inch in length.

Life History.—This is practically the same as for the black plant-bug.

Nature of Work.—Like many of the plant-bugs, this species causes a yellow spotting of the leaves, as shown in Fig. 190. Infested plants often dry up or become stunted.

Distribution.—This species occurs throughout the northern and central parts of the State.

Food Plants.—The grains and grasses are ordinarily infested, including barley, oats and wheat.

Control.—As the attacks of this bug are usually spasmodic and of short duration, control measures are not likely to be warranted. However, should a serious invasion occur, the remedies as recommended for the black plant-bug and the tarnished plant-bug may be used.

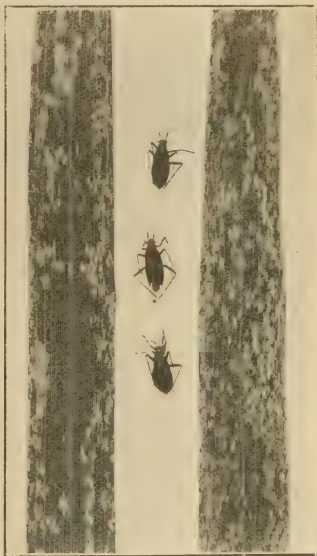


Fig. 190.—The Pacific plant-bug, *Thyrillus pacificus* Uhler. Adults and their work on wheat. Natural size. Specimens taken at Redding by Leroy Childs. (Original)

COLEOPTERA (Order)

SHEATH-WINGED INSECTS

BEETLES

This is the largest order of insects and contains about as many described species as all the other orders combined. It also comprises forty per cent of all the known species in the animal kingdom.

The members are easily recognized by the hard, leathery wing-covers or elytra, which hide and protect the functional second pair of wings and the abdomen. All have biting and chewing mouth-parts and undergo complete transformations or metamorphoses, there being four distinct stages in the life cycle. The larvæ are more or less worm-like and all have six functional legs excepting practically all of the snout-beetles, or weevils, the larvæ of nearly all of which are legless. The larvæ of the June beetles and others having a short, thick body are called grubs. The pupal stage is quiescent.

While most of the beetles feed on plants, many are decidedly beneficial, particularly those known as tiger beetles, predaceous ground beetles and ladybird beetles, and a great majority seem to be of no real economic importance.

CARABIDÆ (Family)

The members of this family are known as predaceous ground beetles and are very numerous. There are five joints to the tarsi and the hind trochanters are egg-shaped. The antennæ are inserted on the side of the head between the base of the jaws and the eyes. The adults feed principally by night upon other insects, being decidedly predaceous in their habits. The larvæ are flattened and protected above with a horny coat. They live in or on the ground and feed upon other insects. The carabids are usually considered exceedingly valuable because of the large numbers of destructive insects which they devour.

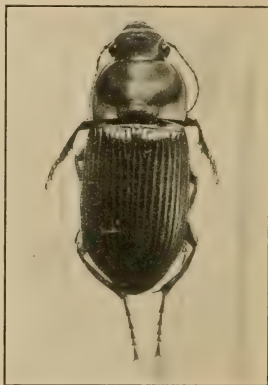


Fig. 191.—The murky ground-beetle, *Harpalus caliginosus* Fab. Female slightly enlarged. This insect is usually predaceous upon other insects and is generally considered of much value to the farmer. Occasionally, however, the adults feed quite extensively upon the fruit of strawberry vines and are responsible for some damage. (Original)

THE RED CARABID

Amara stipida Leconte

Description.—The beetles are reddish-brown with the elytra slightly darker than the head and prothorax, which are often decidedly red. The antennæ and legs are amber. The elytra are strongly carinated. The average length is $\frac{1}{2}$ inch and the width $\frac{1}{8}$ inch.

Life History.—Though the life history of this beetle has not been worked out it is well known that the adults and larvæ are efficient pre-

dators upon many injurious insects. Occasionally, however, the adults injure berries, but to no great extent, and the farmer can well afford to allow a slight toll for the very efficient work done in the destruction of more serious insect pests.

Distribution. — This beetle occurs throughout the central part of the State and is especially abundant in the Sacramento Valley.

Food Plants.—The fruit of strawberries is often attacked by the adults, which may do serious damage in a very short time.

THE COMMON BLACK CALOSOMA

Calosoma semilare Leconte¹²⁸

(Fig. 192)

Description. — The beetles are dull black throughout and well illustrated in Fig 192. The length averages about $\frac{7}{8}$ inch and the width one third the length. The larvæ are shiny black with white areas on the sides and ventral surface. When full-grown they average 1 inch in length.

Life History. — The adults and larvæ appear in February and March and during the spring and summer are often quite numerous on roads and in the fields, where cutworms and armyworms abound. Both stages live primarily on the ground and are exceedingly active, the adults being specially fleet on foot. Their attacks on other insects are usually vicious and their work often phenomenal in the reduction of caterpillars.

Nature of Work.—The young and adults devour caterpillars, which they tear to pieces with the strong jaws.

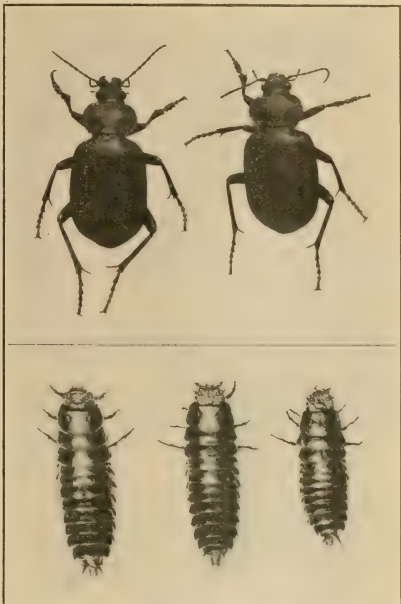


Fig. 192.—The common black *Calosoma*, *Calosoma semilare* Lec. Adults and larvæ. Slightly enlarged. (Original)

¹²⁸There are four other common beneficial species of *Calosoma* in the State as follows: *Calosoma cancellatum* Esch. (Fig. 193) is about as large as *C. semilare* Lec., but is more elongate and has a slightly greenish color. It is found in most parts of the State generally in fields and gardens. *Calosoma simplex* Lec. is also similar to *C. semilare* Lec., but is smaller and smoother on the back. It is abundant in the southern San Joaquin and Mojave valleys. *Calosoma lucatum zimmermanni* Lec. is shorter and rougher than any of the above species and is also wingless. It is found in the northern part of the State and in the high Sierras. *Calosoma scrutator* Fab. is larger than any of the others mentioned, being about 1 inch long. The elytra are iridescent green with a gold line around the margin. The remainder of the body is dark metallic blue or purplish. The beetle occurs in the lower Sacramento and at various places in the San Joaquin Valley.

Distribution.—This is a very common species in all parts of the State.

Hosts.—Cutworms and armyworms are the favorite food of this beetle, but almost any caterpillar may be attacked.



Fig. 193.—*Calosoma lara-tum zimmermanni* Lec. at top, about natural size. *Calosoma cancellatum* Esch. at the bottom, slightly enlarged. (Original)



Fig. 194.—*Calosoma scrutator* Fab. Female, slightly enlarged. (Original)

THE BEET CARRION BEETLE¹²⁹

Silpha opaca Linnaeus (Family Silphidae)

Description.—The beetles are black with the tip of the abdomen dull red. They are decidedly flattened and elongate in shape. The wing covers are very thin and have a small prominence near the middle of each. The length is about $\frac{3}{4}$ inch. The larvæ are shiny black, flat and distinctly segmented.

Life History.—The eggs are laid in decomposing plants or animal tissues, upon which the young begin to feed as soon as hatched. They are nocturnal in habits, though they are often seen wandering about during the day. Occasionally the larvæ attack the foliage and roots of plants. Pupation takes place in the ground, within three or four inches of the surface. The winter is passed in the pupal and adult stages. There is one brood a year.

Nature of Work.—The larvæ feed upon the roots and leaves, often devouring only the epidermis of the latter. They have been reported as doing serious damage to crops in England.¹³⁰

¹²⁹Chittenden, F. H., Bul. No. 43, Bur. Ent. U. S. Dept. Agric., pp. 19-20, 1903.

¹³⁰Insect Life, Vol. I, p. 259, 1889.

Distribution.—This species occurs to a limited extent in the more desert parts east of the Sierras in the State.

Food Plants.—The larvæ feed principally upon decayed plants and carrion, but also attack living plants, including beets (mangels and sugar), marigolds and grasses.

Control.—Clean culture and thorough cultivation will usually suffice to prevent any serious attacks from this beetle. Fall plowing and the application of poison sprays are also recommended. Control measures, however, are doubtfully profitable for this insect.

THE GARDEN CARRION BEETLE

Silpha ramosa Say¹²¹

(Fig. 195)

Description.—The beetles are rather broad and decidedly flat, dull black with a velvety sheen. The prothorax, head and body are smooth while the elytra or wing covers are very rough. The eyes are yellow. The length is slightly more than $\frac{1}{2}$ inch and the width about $\frac{5}{16}$ inch. The antennæ are short with the apical joints noticeably enlarged (Fig. 195). The larvæ are shiny black, flat and distinctly segmented, the body appearing as if covered with closely joined plates. They are from $\frac{1}{4}$ to $\frac{1}{2}$ inch long.

Life History.—The life history is practically the same as that of the beet carrion beetle (*Silpha opaca* Linn.).

Nature of Work.—The larvæ feed principally upon decomposed vegetable and animal matter, but are thought to attack the roots and foliage of plants, though this is very uncertain. The adults feed almost entirely upon carrion.

Distribution.—This is a very common beetle throughout the State, especially in damp localities.

Food Plants.—Various grasses, garden and field crops are said to be attacked by the larvæ and adults.

Control.—Control measures are not at all necessary for this insect.



Fig. 195. — The garden carrion beetle, *Silpha ramosa* Say. Female slightly enlarged. (Original)

COCCINELLIDÆ (Family)

LADYBIRD BEETLES

This family of beetles is generally considered one of the most important and beneficial of all the insects. Only one injurious plant-feeding species, *Epilachna corrupta* Muls., is said to have been found in California, while many other species are particularly noted for their predaceous habits in feeding upon scale insects (*Coccida*) and the plant lice (*Aphididæ*).

Eggs.—The eggs vary considerably with the different members of the family and are seldom if ever observed. Those most conspicuous

¹²¹Another carrion beetle, *Silpha lapponica* Hbst., is very common in the southern part of the State. It is much smaller than *Silpha ramosa* and is easily distinguished by the fine yellow hair which completely hides the dorsum of the prothorax.

are the salmon-colored egg masses of the *Hippodamia* spp., which are laid on ends, not unlike bunches of cigars. Others are deposited singly upon or underneath individual scale insects, in the egg-masses of mealy bugs or among plant lice.

Larva.—The young larvæ are exceedingly active and begin to feed soon after hatching. As the period of growth is short, their ability to consume food must be great, and we find them unexcelled as predators. They have rather long, pointed and flattened bodies, well developed mouth-parts and six legs. The colors are exceedingly variable, the



Fig. 196.—The signet ladybird beetle, *Hippodamia 5-signata* Kirby. Greatly enlarged. (Drawing by Birdnekoﬀ, Mo. Bul. Cal. Hort. Com.)



Fig. 197.—Leconte's ladybird beetle, *Hippodamia lecontei* Muls. Greatly enlarged. (Drawing by Birdnekoﬀ, Mo. Bul. Cal. Hort. Com.)



Fig. 198.—*Hippodamia ambigua* Lec., the unspotted form of *Hippodamia convergens* Guer. Greatly enlarged. (Drawing by Birdnekoﬀ, Mo. Bul. Cal. Hort. Com.)

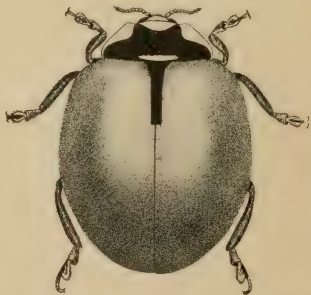


Fig. 199.—The California red ladybird beetle, *Coccinella californica* Mann. Greatly enlarged. (Drawing by Birdnekoﬀ, Mo. Bul. Cal. Hort. Com.)

bodies are hairy, some being covered with long threads of white wax. Besides the covering, they are protected by offensive secretions and are not generally preyed upon by insectivorous animals. During their growth they moult four times and when fully matured seek shelter to pupate.

Pupa.—The larvæ, not having a waxy or exceedingly hairy or spiny covering, usually hang by the tail and pupate with the head downward,

while many of the covered ones pupate within the larval skins, which give ample protection. Offensive liquids are also secreted by the pupae for protective purposes. Nearly all have the ability to move the body very rapidly when disturbed.

Adults.—The beetles emerge through slits in the pupal skins and are exceedingly active, feeding throughout their existence. In size they vary in this State from $\frac{1}{16}$ to nearly $\frac{3}{8}$ inch in length. The color of



Fig. 200.—*Erochomus californicus* Casey. Greatly enlarged. (Drawing by Birdnekoﬀ, Mo. Bul. Cal. Hort. Com.)

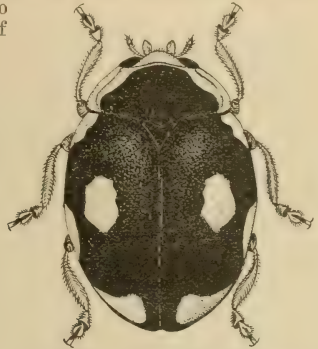


Fig. 201.—*Hyperaspis undulata* Say. Greatly enlarged. (Drawing by Birdnekoﬀ, Mo. Bul. Cal. Hort. Com.)

the larger species is usually showy and of many shades and combinations, but the majority are dull and inconspicuous. The males are somewhat smaller than the females and sometimes with slightly different colorations. The

winter is passed in hibernation. In some species thousands of individuals collect in the mountains in great numbers, where the winter is spent among the leaves, rocks and pine needles, under the snow. With the first warm spring weather these



Fig. 202.—The mourning Hyperaspis, *Hyperaspis murens* Lec. Greatly enlarged. (Author's illustration, Mo. Bul. Cal. Hort. Com.)



Fig. 203.—*Hyperaspis spiculata* Fall. Greatly enlarged. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

emerge from the winter quarters and migrate to the lower valleys and disperse to give rise to succeeding summer generations.

The coccinellids differ from the closely related chrysomelids by having three instead of four tarsal joints and the antennae enlarged at the tips.

THE TWO-STABBED LADYBIRD BEETLE

Chilocorus bicuter Mulsant

(Fig. 204)

Description.—The adults are broadly oval and about $\frac{3}{16}$ inch long. The color is shiny black with two round, blood-red spots upon the elytra. The extreme margins of the prothorax are pale. The underside of the abdomen is red. The larvæ are very spiny, dark in color, with a yellow transverse band across the middle.

Distribution.—This is one of the commoner native ladybird beetles and is to be found in almost every part of the State.

Hosts.—The larvæ and adults are voracious feeders upon the pernicious or San Jose scale, *Aspidiotus perniciosus* Comst., the young of the black scale, *Saissetia oleæ* (Bern.), mealy bugs, oyster-shell scale, *Lepidosaphes ulmi* (Linn.), European or Italian pear scale, *Epidiaspis piricola* (Del Guercio), the European elm scale, *Gossyparia ulmi* (Linn.) and other scale insects.



Fig. 204.—The two-stabbed ladybird beetle, *Chilocorus bicuter* Muls. Larvæ, pupæ and adults, enlarged slightly more than twice. (Original)



Fig. 205.—Adult of the mealy bug destroyer, *Cryptolemus montrouzieri* Muls. Greatly enlarged. (Author's illustration, P. C. Jr. Ent.)

THE MEALY BUG DESTROYER

Cryptolemus montrouzieri Mulsant

(Figs. 205, 206 A)

Description.—The adults are as large as the ordinary red ladybird beetle, but decidedly pointed posteriorly. They are black, with the head, prothorax and posterior ends of the elytra cinnamon red, and the entire body is covered with fine, light hair. The larvæ are yellow and covered with long filaments of white flocculence (Fig. 206 A). The eggs are regularly oval, very small and lemon yellow. They are deposited singly among the eggs of the

mealy bugs and are therefore very difficult to find.

Distribution.—This species was introduced into California by Albert Kæbele and is redistributed from time to time by the State

Insectary. It now occurs throughout the mealy-bug infested districts of the State.

Hosts.—This is by far the most important natural enemy preying upon the various species of mealy bugs, including *Pseudococcus citri*, *P. longispinus* and *P. bakeri*. In not a few cases it has done excellent work in controlling the citrus mealy bug.

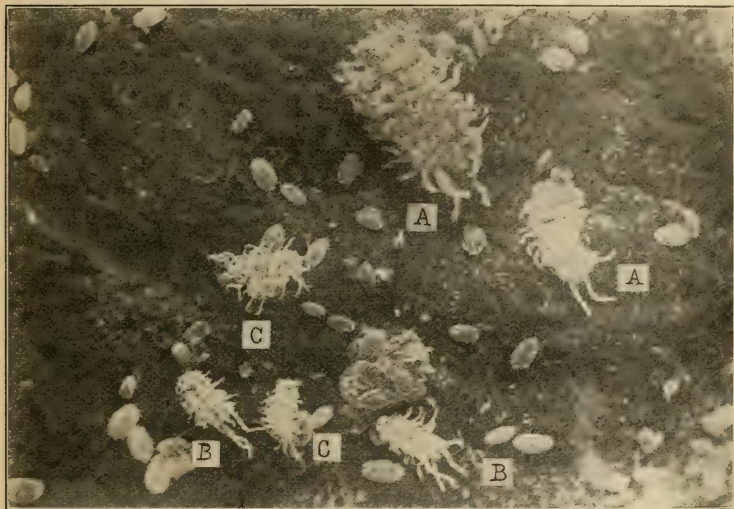


Fig. 206.—Larvæ of ladybird beetles. A, *Cryptolomus montrouzieri* Muls.; B, *Scymnus bipunctatus* Kugel.; C, *Scymnus guttulatus* Lec. (Author's illustration, P. C. Jr. Ent.)

THE COMMON BLACK-SPOTTED RED LADYBIRD BEETLE¹³²

Hippodamia convergens Guerin

(Figs. 198, 207)

Description.—This is the most common of all ladybird beetles in California and is easily distinguished by the red color and the twelve black spots on the elytra. The head and thorax are black, the latter with two narrow lateral white margins and a very small median white spot at the base. The eggs are salmon-colored and deposited in clusters not unlike bunches of cigars stood on end. The young larvæ are nearly black and exceedingly small with rather long legs. Full-grown larvæ are nearly $\frac{1}{2}$ inch long and have several reddish or salmon-colored spots on the dorsum. The pupæ vary from yellow to reddish with black markings. All stages of the beetle exist throughout the summer months and may be found almost anywhere.

¹³²The common red ladybird beetle formerly known as *Hippodamia ambigua* Leconte, is a varietal form of the above species. There are no black spots upon the wing covers, but the size, shape and other markings are identical with the spotted form. See Fig. 198.

Distribution.—This is the common ladybird beetle throughout the entire State. The adults hibernate in great colonies in the high Sierras, from whence they descend into the lowlands as soon as warm weather melts the snow in the spring.

Hosts.—All stages feed upon soft-bodied insects, such as plant lice and scale insects. The larvæ are also, at times, cannibalistic. The principal food consists of plant lice, chief of which are the melon aphid, *Aphis gossypii* Glover, the destructive pea aphid, *Macrosiphum pisi* (Kalt.), the bean aphid, *Aphis rumicis* Linn., and the woolly apple aphid, *Eriosoma lanigera* (Hausm.).

THE VEDALIA

Novius cardinalis (Mulsant)

(*Vedalia cardinalis* Mulsant)

(Fig. 208)

Description.—The beetles are slightly less than $\frac{1}{4}$ inch in length and oval in shape. The color pattern is very pronounced and striking, being red and black, as shown in Fig. 208. In the females red predominates, while in the males there is more black. Both sexes are covered with fine, light-colored hair. The larvæ are often over $\frac{1}{2}$ inch long and lead-gray in color with reddish sides. They are usually covered with whitish powder from the egg-sacs of the cottony cushion scale. The eggs are a little larger than those of *Novius kæbelei*, but are the same color and laid in similar places. The young feed upon the eggs and young scales and do great execution. The pupal stage is passed in the larval skin upon the leaves and limbs of the trees.



Fig. 208.—Adult female of the Vedalia, *Novius cardinalis* (Muls.). Drawing, showing the color pattern. (After U. S. Dept. Agric.)

Distribution.—The Vedalia is quite common throughout the citrus-growing sections of the State. It disappears with the host and is constantly being sent out by the State Insectary. It was introduced into California by Albert Kæbele of the United States Department of Agriculture.

Hosts.—It feeds entirely upon the eggs and young of the cottony cushion scale (*Icerya purchasi*). To this beetle is accredited the salvation of the citrus industry in California, which was threatened with destruction by the above scale.

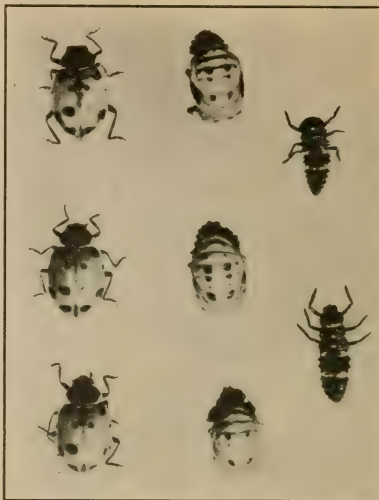


Fig. 207.—The common black-spotted red ladybird beetle, *Hippodamia convergens* Guer. Adults, pupæ and larvæ. Enlarged twice. (Original)

KÆBELE'S LADYBIRD BEETLE

Novius kabelei (Olliff)(*Vedalia kabelei* Olliff)

(Fig. 209)

Description.—The adults are smaller than those of the *Vedalia*, being not longer than $\frac{1}{8}$ inch; the males are bright red with dark markings, as shown in Fig. 209; the females are red with dark head, prothorax, and marginal spot near the middle of each wing cover. Both sexes are covered with fine,

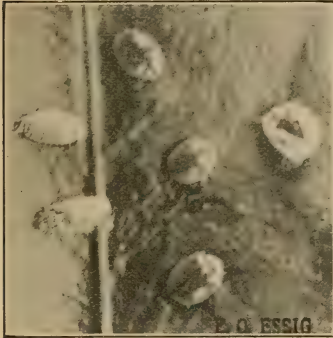


Fig. 209.—Kæbele's ladybird beetle, *Novius kabelei* Olliff. Larvæ, pupa and adults at left. Enlarged twice. (Author's illustration, P. C. Jr. Ent.). Drawing of adult male at right, greatly enlarged. (Drawing by Birdnekoﬀ, Mo. Bul. Cal. Hort. Com.)

short hairs. The larvæ are dark red and about $\frac{1}{4}$ inch long. The small, oblong, red eggs are deposited by the females on the egg-sacs of the host and hatch within a few days. The young immediately enter the egg-sac and begin feeding upon the eggs and young hatched scales. They pupate within their larval skins on the trees.

Distribution.—This beetle is found throughout the citrus-growing sections of the State. It was first introduced by Albert Kæbele.

Hosts.—This species feeds on the cottony cushion scale (*Icerya purchasi*) and is often more numerous and does greater execution than the *Vedalia*, for which it is commonly mistaken.

Lindorus lopanthus (Blaisdell)(*Rhizobius lopanthæ* Blaisdell)(*Rhizobius toowoombæ* Blackburn)

(Fig. 210)

Description.—The beetles are rather broadly-oval in shape and about $\frac{1}{8}$ inch long. The color is bright metallic black or bronze. The head and thorax are reddish-brown with a dark spot at the middle base of the latter. This species is very often confused with *Scymnus marginicollis*, but may readily be distinguished from it by the lustrous bronze color and the erect hair on the dorsum. The larvæ are light-brown in color with an elongated yellow spot on the middle of the back.

Distribution.—This species was introduced into California by Albert Koebele and has become generally established in the central and southern parts of the State.

Hosts.—The larvæ and adults of this beetle feed upon red scale (*Chrysomphalus aurantii*), yellow scale (*Chrysomphalus citrinus*), ivy scale (*Aspidiotus hederae*), pernicious or San Jose scale (*Aspidiotus perniciosus*), purple scale (*Lepidosaphes beckii*), the citrus mealy bug (*Pseudococcus citri*) and black scale (*Saissetia oleæ*).

THE ASHY-GRAY LADYBIRD BEETLE¹²⁷

Olla abdominalis (Say)
(*Cycloneda abdominalis* Say)
(Fig. 211)

Description.—The beetles have a yellowish-gray ground color with many small dark spots on the dorsum. The body is of average size, being about $\frac{1}{4}$ inch long and distinctly broad

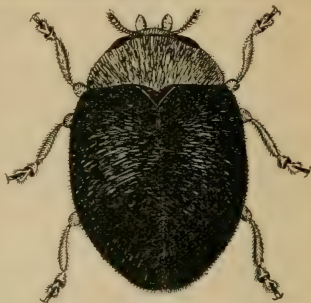


Fig. 210.—*Lindorus lopanthus* Blaisd. Greatly enlarged. Drawing by Bird-nekoff, Mo. Bul. Cal. Hort. Com.)

or almost hemispherical in shape. The eggs are light orange-yellow and laid on end in clusters much the same as those of the *Hippodamia convergens* Guer. The larvæ vary from $\frac{1}{2}$ to $\frac{3}{4}$ inch in length, are dark with yellow spots on the sides and dorsum. The pupæ are gray with dark spots on the back and large dark blotches on the sides and ventral surface.

Distribution.—This species occurs throughout the State, but is more abundant in the central and southern parts, especially in the coast counties from Santa Barbara south.



Fig. 211.—The ashy-gray ladybird beetle, *Olla abdominalis* (Say). Male and female. Enlarged nearly three times. (Original)

Hosts.—The walnut plant louse is a favorite host of this beetle and is often almost entirely subdued by it. Other lice are also attacked.

THE STEEL-BLUE LADYBIRD BEETLE

Oreus chalybeus (Boisduval)

(Fig. 212)

Description.—The adult is metallic, steel-blue or green in color, almost hemispherical in shape and between $\frac{1}{2}$ and $\frac{3}{16}$ inch in diameter.

¹²⁷The eyed ladybird beetle, *Olla* (*Cycloneda*) *oculata* Fab., is a dark form of this species. The adults are broadly rounded, 3-16 inch long and three fourths as wide. The head is pale; the pronotum black with pale margins; the wing covers are black with a large, irregular red or orange-colored spot near the middle of each. The ventral surface of the head and thorax and the bases of the legs are black, while the tips of the legs and the posterior end of the abdomen are pale. *Olla plagiata* Casey is also a synonym of *Olla abdominalis* Say.

In the male the front tip of the pronotum is yellow. The posterior half of the abdomen in both sexes is dull red. The larva is light yellow



Fig. 212.—The steel-blue ladybird beetle, *Orcus chalybeus* (Boisd.). Larvæ, pupæ and adults, enlarged three times. Specimens collected at Carpinteria by C. W. Beers. (Original)

or amber with dark head and dark markings on the dorsum of the thorax and abdomen, as shown in Fig. 212. The spines are long, forked and black. The length when full-grown is nearly $\frac{3}{4}$ inch. The pupa greatly resembles the larva in color, but is distinctly wider. The eggs are elongate with pointed ends and with a noticeable projection of secretion on the apical end. They are light yellow and laid in loose clusters, attached by one end.

The larva is light yellow or amber with dark head and dark markings on the dorsum of the thorax and abdomen, as shown in Fig. 212. The spines are long, forked and black. The length when full-grown is nearly $\frac{3}{4}$ inch. The pupa greatly resembles the larva in color, but is distinctly wider. The eggs are elongate with pointed ends and with a noticeable projection of secretion on the apical end. They are light yellow and laid in loose clusters, attached by one end.

Distribution. — This species was originally distributed throughout the entire southern part of the State, but is now

almost entirely confined to the districts around Barbara County, where it is well established. It was introduced into California by Albert Kæbele.

Hosts.—This beetle feeds upon many armored coccids, including red scale (*Chrysomphalus aurantii*), yellow scale (*Chrysomphalus citrinus*), *Chrysomphalus rossi*, purple scale (*Lepidosaphes beekii*), pernicious or San Jose scale (*Aspidiotus perniciosus*) and black scale (*Saissetia oleæ*).

THE STRIPED LADYBIRD BEETLE

Paranemia vittigera (Mannerheim)

(*Megilla vittigera* Mannerheim)

(Fig. 213)

Description.—The beetles vary from straw or light pink to almost bronze and have black heads, legs, two black irregular blotches on the prothorax and three black longitudinal stripes on the wing covers. They are about $\frac{1}{4}$ inch long.

Distribution.—The adults hibernate in quite large colonies and are found in most sections of the State, especially in the southern part.



Fig. 213.—The striped ladybird beetle, *Paranemia vittigera* (Mann.). Enlarged three times. (Original)

They seem to prefer damp places and are usually common in sugar beet fields. At Oxnard, California, the writer found this beetle in great numbers.

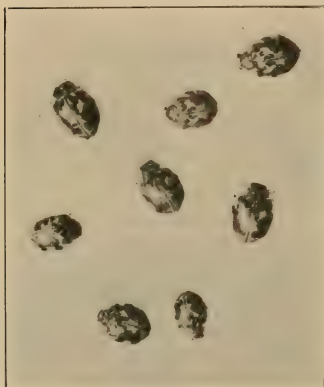
Hosts.—This species feeds upon root lice, like the beet root aphid (*Pemphigus betæ*) and other soft-bodied insects.

THE SMALL GRAY LADYBIRD BEETLE

Psyllobora tadata Leconte

(Fig. 214)

Description.—The adults vary from light cream-color to gray and are mottled with fine irregular brown spots, giving a salt and pepper effect. They are oblong and very small, scarcely exceeding $\frac{1}{8}$ inch in length. The larvæ are light gray or straw-colored and about $\frac{3}{8}$ inch long. All stages are exceedingly active.



Distribution.—This is a native species common throughout the entire State.

Hosts.—The young and adults feed upon young coccids and especially upon mites, and may be found in great numbers in the citrus orchards in the southern part of the State. Mr. Geo. P. Weldon observed the beetles devouring the red spider in the apple orchards of Humboldt County.

Fig. 214.—The small gray ladybird beetle, *Psyllobora tadata* Lec. Enlarged three times. Specimens collected at Ventura by S. H. Essig. (Original)

THE BLACK LADYBIRD BEETLE

Rhizobius ventralis Erickson

(Fig. 215)

Description.—The adults are smaller than those of the common red ladybird beetle, rather oval in shape, black and covered with fine, erect hairs which give them a grayish appearance. They are about $\frac{1}{4}$ inch long. The abdomen is salmon-colored. The larvæ are dark brown or black and covered with many spines.

Distribution.—This beetle occurs throughout the entire State where the black scale is at all common. It was imported by Albert Kœbele, especially as an enemy of black scale (*Saissetia oleæ*).

Hosts.—The larvæ and adults feed upon the young and eggs of the black scale (*Saissetia oleæ*), the hemispherical scale (*Saissetia hemisphærica*), various mealy bugs (*Pseudococcus* spp.) and many of the armored scales.

Scymnus guttulatus Leconte

(Fig. 216)

Description.—The adults are oval-elongate in shape and scarcely $\frac{1}{8}$ inch in length.

The general color is black, mottled with reddish-brown, as shown in Fig. 216. The body is covered with fine, short hair. The larvæ are about $\frac{1}{4}$ inch long with yellow bodies, which are entirely covered with long, white, cottony filaments. The nymphs remain in the old larval skins in secluded quarters throughout the pupal stage.

Distribution.—This is a native species, occurring throughout the entire State, especially upon oak trees. It has often been distributed by the State Insectary.

Hosts.—The larvæ and adults work upon various native mealy bugs as well as upon the citrus mealy bug (*Pseudococcus citri*) and the long-tailed mealy bug (*Pseudococcus longispinus*).

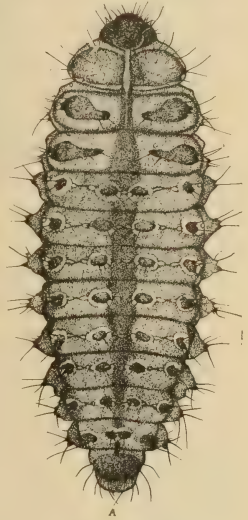


FIG. 215.—The black ladybird beetle, *Rhizobius ventralis* Er. Larva and adult, greatly enlarged. (Author's illustration, P. C. Jr. Ent.)



FIG. 216.—*Scymnus guttulatus* Lec. Adult female, enlarged five times. (Author's illustration, P. C. Jr. Ent.)

THE MARGINED SCYMNUS

Scymnus marginicollis Mannerheim

(Fig. 217)

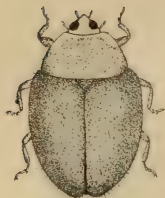


Fig. 217.—The margined *Scymnus*, *Scymnus marginicollis* Mann. Adult female, enlarged ten times. (Author's illustration, P. C. Jr. Ent.)

Description.—The adults are small dull-black beetles with reddish prothorax and head. On the prothorax there is a black spot at the base in the males and which occupies nearly the entire base in the females. It is less than $\frac{1}{8}$ inch long and distinguished from *Lindorus lophanthus* by its dull color, the latter being shiny.

Distribution.—This is a native species common throughout the entire State, especially along the coast.

Hosts.—The beetle feeds upon many species of aphids and coccids, and is especially destructive to the perniciosus or San Jose scale in the north and to the red scale and purple scale in the south.

THE CLOUDY SCYMNUS

Scymnus nebulosus Leconte

(Fig. 218)

Description.—The beetles are exceedingly small, being less than $\frac{1}{8}$ inch in length. They are somewhat elongated in shape and vary from light to dark brown in color, with indistinct dark markings. The larvæ are covered with long, white, cottony filaments.

Distribution.—The cloudy *Scymnus* occurs throughout the central and southern parts of the State.

Hosts.—The writer has collected the larvæ of this species in large numbers in the canyons of Ventura County, where they were feeding upon a small native plant louse (*Eichochaitophorus populifolii* Essig). Quayle reports it as feeding upon red and purple scale. It also preys upon various species of mealy bugs, doing effectual work upon the citrus species (*Pseudococcus citri*).



Fig. 218.—The cloudy *Scymnus*, *Scymnus nebulosus* Lec. Adult, enlarged five times. (After Quayle, Cal. Agrcl. Exp. Sta.)

THE SMALL BROWN LADYBIRD BEETLE

Scymnus sordidus Horn

(Fig. 219)

Description.—This is a very small light brown beetle, scarcely more than $\frac{1}{8}$ inch long and covered with light-colored pubescence. The eggs are very minute and deposited in suitable feeding grounds. The larvæ cover themselves with a thick coat of long, white, waxy flocculence and greatly resemble mealy bugs. Though small they are voracious feeders, especially upon the smaller species of plant lice and upon young scale insects. The pupæ are formed within the old larval skins.

Distribution.—The beetle occurs throughout the entire State, but is more abundant in the south.

Hosts.—This species preys upon mealy bugs, the young of the armored scales, plant lice, including *Aphis gossypii* (Glover and other

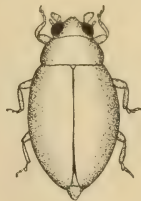
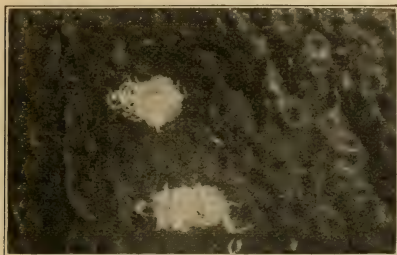


Fig. 219.—The small brown ladybird beetle, *Scymnus sordidus* Horn. Larvæ at left, enlarged twice; adult female at the right, enlarged ten times. (Author's illustration, P. C. Jr. Ent.)

soft-bodied insects. Large numbers of these ladybird beetles are to be found in the citrus groves of the southern coast counties.

THE MINUTE BLACK LADYBIRD BEETLE

Stethorus vagans (Blackburn)

(*Scymnus vagans* Blackburn)

(Fig. 220)

Description.—This is one of the smallest species and is seldom observed by the average orchardist, though often quite abundant upon the trees. The adults are shiny black, oblong and scarcely $\frac{1}{16}$ inch long.

Distribution.—This beetle was imported from Australia by Geo. Compere and is quite generally distributed throughout the southern part of the State.

Hosts.—The minute black adults may be easily observed feeding upon small mites and red spiders. They are often abundant in citrus orchards, devouring the citrus red spider (*Tetranychus mytilaspidis* Riley), the two-spotted mite (*Tetranychus telarius* Linn.) and the red spider (*Bryobia pratensis* Garman).



Fig. 220.—The minute black ladybird beetle, *Stethorus vagans* (Blackb.). Adult, enlarged fourteen times. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

ELATERIDÆ (Family)

WIREWORMS, CLICK-BEETLES, SNAP-BEETLES

(Fig. 221)

The beetles belonging to this family greatly resemble the buprestids in general appearance, but may be at once separated from them by the sharp-pointed posterior angles of the prothorax, the lack of metallic colors and the apparatus on the ventral surface of the prothorax and mesothorax which enables the beetles to throw themselves considerable distances when lying on the back. This ability to jump has given rise to the common names "click-beetles" and "snap-beetles." The larvæ are cylindrical and have a hard shiny covering which is distinctly segmented. They are known everywhere as "wireworms."



Fig. 221.—Wireworms, the larvæ of click-beetles, in a potato. Slightly enlarged. (Original)

THE SUGAR-BEET WIREWORM¹²⁴*Limoniæ californicus* (Mannerheim)¹²⁵(*Cardiophorus californicus* Mannerheim)

(Fig. 222)

Description.—The adults are elongate, light or dark brown, covered with fine hair and the dorsum is coarsely punctured. The length averages about $\frac{2}{3}$ inch, the width one third the length. The eggs are

¹²⁴All of the information regarding this pest has been taken from Bul. No. 123, Bur. Ent., U. S. Dept. Agric., 1914, by J. E. Graf. Mr. Graf also furnished specimens of the beetles for illustrative purposes.

¹²⁵Dr. E. C. Van Dyke reports two closely allied species which are also injurious to sugar beets. *Limoniæ infuscatus* Mots. has the same general distribution and is usually associated with the above, but is often the most injurious. It is especially common in the interior valleys and the sandy coast river valleys. *Limoniæ canus* Lec. has a similar distribution, but is more restricted to sandy dunes and river banks. It is also probably less harmful.

somewhat elliptical, white and exceedingly minute. The larvæ resemble the ordinary wireworms, are subcylindrical, shiny yellowish-brown with head and ventral surface darker brown. The length averages about $\frac{1}{8}$ inch and the diameter 3-25 inch. The pupæ resemble very much the adults in and size, but are much lighter in color until nearly mature.

Life History.—The eggs are laid in the spring. They are deposited in the damp soil within one and one half inches of the surface. From twenty-five to sixty are laid by a single female. They hatch in from fifteen to thirty-three days and the larvæ soon begin to feed, continuing to do so throughout their long life of about three years. When ready to pupate a small oval cell is constructed usually within six inches of the surface of the



Fig. 222.—Adults of the sugar-beet wireworm, *Limonius californicus* Mann. Natural size. Specimens taken at Compton by J. E. Graf. (Original)

ground. The pupal stage requires from twenty-five to thirty-two days, or about one month. A complete life cycle requires four years. The adults feed to some extent upon old beet tops and the roots of beets and other plants, but do little or no damage, while the wireworms are very serious pests.

Nature of Work.—The larvæ feed upon the roots of the young plants, cutting off the tap-roots and often working up the stems. They also attack the sprouting seed of beans and destroy the plants after they come up. The sugar-beet wireworm is considered the worst beet and bean pest in the State.

Distribution.—This species is most abundant in the coast belt from Mendocino County to the southern part of the State. It prefers sandy river bottom land.

Food Plants.—Graf records the following food plants: alfalfa, wild aster, beets (sugar and garden), lima beans, chrysanthemum, corn, dock, Johnson grass, mustard, nettle, pigweed and potato.

Control.—Control measures have not yet been fully worked out, but Graf has laid down some important methods which will serve to materially lessen the attacks. They are: (1) plowing in the fall of the year to destroy pupæ in the dry soil; (2) planting early to give the beets a good start before the wireworms begin extensive feeding; (3) clean culture to eliminate shelter for the adults and to expose them to natural enemies and to compel them to seek shelter elsewhere.

BUPRESTIDÆ (Family)

METALLIC WOOD-BORERS OR BUPRESTIDS

The buprestids greatly resemble the click beetles (*Elaterida*), but are easily distinguished by their metallic iridescence, finely serrated antennæ, the rigid union of the first two abdominal segments on the

ventral side and the absence of the power of springing when placed on the back. The larvæ are enlarged near the head and thus resemble a horseshoe nail. They are wood borers, feeding beneath the bark or in the solid wood. The common representative of this family is the flat-headed apple-tree borer which occurs throughout the State and country.

THE OAK TWIG-GIRDLER¹²⁶

Agrilus politus Say

(Fig. 223)

Description.—The beetle is about $\frac{5}{16}$ inch long, one fifth as wide and the color varies from metallic bronze to purple or green. The larva is very slender, white or light yellow, distinctly segmented with the largest segment near the head. The average length is about 1 inch.



Fig. 223.—The oak twig-girdler, *Agrilus politus* Say. Adult and larvæ, enlarged twice. Specimens taken at Walnut Creek by Leroy Childs. (Original)

Life History.—The life history is not well understood, but the eggs are probably laid on the small branches at the axil of a leaf or in a fork, as the young larva usually enters at such points. The burrow is made just beneath the bark, in the form of a regular spiral, and completely girdles the twig, causing that portion above the spiral to die. Pupation takes place near the bottom of the spiral and the adults begin to issue in April. There is evidently but one brood a year.

Nature of Work.—The first symptoms appear in the form of numerous dead twigs throughout the tree. If the bark is removed at the base of such twigs and a spiral burrow disclosed, it is the work of this buprestid borer.

Distribution.—The oak twig-girdler is found throughout the State, specimens having been collected in the southern, middle and northern parts, wherever the host plants occur, especially the willow.

Food Plants.—The favorite host is the willow, but the coast live oak (*Quercus agrifolia*) is often severely damaged by attacks of the beetle. Other food plants are California buckeye and hazelnut.

Control.—Pruning out and burning the infested twigs during the fall and winter of the year has been recommended as an effective means of controlling this pest.

Natural Enemies.—Mr. Leroy Childs records an undetermined hymenopterous parasite attacking the larvæ.

¹²⁶Childs, Leroy, Mo. Bul. Cal. Hort. Com., III, pp. 150-155, 1914.

THE FLAT-HEADED APPLE-TREE BORER

Chrysobothris femorata Fabricius

(Fig. 224)

Description.—The beetles are oblong, flattened and metallic greenish-black or grayish in color. On each wing cover there are three raised longitudinal lines which are traversed by two brass-colored depressions, dividing the surface into three nearly equal dark areas. The under surface is metallic bronze and the feet green. The females are about $\frac{1}{2}$ inch long and the males are slightly smaller and have green heads. The eggs are yellow, ribbed, with one end flattened and are 1-50 inch long. The full-grown larvæ are white or yellow and from $\frac{1}{2}$ to over $\frac{3}{4}$ inch long. The anterior portion, just behind the head, is enormously enlarged and flat-



tened. This character is responsible for the common name, though in reality the head proper is very small and easily distinguished by the black jaws. No legs are present. The pupæ are white or yellowish, assuming the colors of the adults as they mature.

Life History. — The eggs are fastened, with a cement at the flattened end, under the loose scales of the bark, or in crevices, either singly or in small groups. After hatching the small larvæ bore into the sapwood, upon which they feed. Young trees may thus be completely girdled by their wide, flattened burrows. As they develop, the larvæ work into the older and firmer wood. When nearly ready to pupate they work upward to the bark, eating nearly through, and form a large cell, where transformation takes



Fig. 224.—The flat-headed apple-tree borer, *Chrysobothris femorata* Fab. Adult at top, larvæ in their burrows in young apple trees at bottom. All enlarged nearly twice. (Adult original. Larvæ, author's illustration, Mo. Bul. Cal. Hort. Com.)

place. The winter is spent in the larval and pupal stages, the adults beginning to emerge in the early spring to begin egg-laying.

Nature of Work.—The bases of young trees are often almost entirely girdled by the burrows of the larvæ. Nursery stock should be closely inspected for such injuries. Older trees are usually attacked only where wounds, sunburns or dead portions occur. From these areas, however, the larvæ often push their burrows into perfectly healthy tissues. Discolorations of the bark above the burrows indicate infestation.

Distribution.—This is a very common pest throughout the entire State and country.

Food Plants.—Many plants are attacked by this beetle, including apple, apricot, ash, mountain ash, beech, box-elder, cherry, chestnut, currant, hickory, horse-chestnut, linden, maple, oak, peach, pear, pecan, plum, prune, raspberry, rose, sycamore and willow. Oak is apparently the normal food plant.

Control.—The first precaution is to thoroughly inspect all nursery stock and see that no infested trees are planted. Trees should also be protected from sunburn and cultivator wounds. A fairly good wash to prevent the attacks on healthy trees is a solution of soft soap, reduced to the consistency of paint, to which is added a strong solution of washing soda. To every 10 or 15 gallons of this mixture add 1 pint of 25 per cent crude carbolic acid. This should be applied in the same way as paint in May or June, and again in July or August. Whitewash applied in the same manner has also proven to be a very good repellent. The larvæ may be dug out with a knife blade or killed with a crooked wire in their tunnels during the late fall of the year.

Natural Enemies.—In some localities natural enemies play quite an important role in the subjugation of this pest. The following hymenopterous parasites have been reared from the larvæ: *Bracon charus* Riley, *Cryptus gallator* Say and *Labena apicalis* Cr.¹³⁷ Woodpeckers also destroy considerable numbers of them.

THE WESTERN TWIG-BORER

Apate punctipennis (Leconte) (Family Bostrychida)

(*Amphicerus punctipennis* Leconte)

(Figs. 225, 226)

Description.—The beetles are dark brown with feet and other portions of the body clothed with fine yellowish-brown hair. The length is about $\frac{1}{2}$ inch and the width $\frac{3}{16}$ inch. The head is held at right angles to and directly beneath the prothorax. The front of the prothorax is covered with distinct spine-like projections which easily distinguish this species from other common twig-borers. The wing covers are coarsely punctured and appear very rough. This species is larger than the Eastern apple twig-borer, *Apate* (*Amphicerus*) *bicaudatus* Say.

Life History.—All that is known of the life history is that the beetles breed in trees and reach maturity in the spring of the year, when they often become quite numerous.

Nature of Work.—In the case of orchard trees, burrows are made into the growing twigs, as shown in Fig. 226. The burrows usually

¹³⁷Insect Life, III, p. 464, 1890.

enter at a bud or in a fork, in which cases gum often exudes to form a large drop. In not a few cases the burrows completely occupy almost the entire twig, which may be nearly severed from the tree.



Fig. 225.—The western twig-borer, *Apate punctipennis* (Lec.). Adults, enlarged twice. (Author's illustration, Mo. Bul. Cal. Hort. Com.)



Fig. 226.—Work of the western twig-borer, *Apate punctipennis* (Lec.), on apricot twigs. Natural size. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

Distribution.¹³⁸—This beetle occurs throughout the central and southern parts of the State, having been recorded from Riverside, San Bernardino, Los Angeles, and San Diego counties by H. C. Fall, from San Joaquin County by Geo. P. Weldon and from Imperial County by Dr. E. C. Van Dyke.

Food Plants.—Mesquit (*Prosopis juliflora*) is reported by Van Dyke as a native host. The beetle has also been reared from apricot, fig, grape, pear and orange. In most cases dead and not living wood was reported infested.¹³⁹

Control.—Control measures are difficult for such a pest and should be applied only when injury warrants, which is very rarely the case. Orchard trees should be kept as healthy as possible, all native trees serving as breeding places destroyed and infested branches pruned out and burned.

THE BRANCH AND TWIG-BORER¹⁴⁰

Polycaon confertus Leconte¹⁴¹ (Family Bostrychidae)

(Fig. 227)

Description.—The beetle is slender, black with brown wing covers and from $\frac{3}{8}$ to $\frac{5}{8}$ inch long. The head is as wide as the prothorax, which is noticeably narrower than the rest of the body.



Fig. 227.—The branch and twig-borer, *Polycaon confertus* Lec. Adult male and female and their work on olive twigs. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

Life History.—

According to Dr. E. C. Van Dyke, the eggs are laid in various dead woods, such as grape, acacia, certain brush woods, etc. The larva develop in them, gradually tunneling the wood in all directions, as is the case with the powder post beetles, and the adults emerge in the early summer. When the beetles have once infested the wood they continue to breed there for many suc-

ceeding generations, or until all of the nutritious parts have been consumed. When they attack the dead twigs of the grape they cause the "die back" to extend further and further into healthy tissue, and thus often do considerable damage.

¹³⁸Fall, H. C., Proc. Cal. Acad. Sci., VIII, p. 124, 1901.

Mo. Bul. Cal. Hort. Com., II, p. 684, 1913.

¹³⁹Mo. Bul. Cal. Hort. Com., II, 684, 1913.

¹⁴⁰Mo. Bul. Cal. Hort. Com., II, pp. 587-589, 1913.

¹⁴¹*Polycaon stoutii* Lec. is much larger and entirely black. It also occurs generally throughout the state and attacks the almond, eucalyptus, Maul oak and coast live oak.

Nature of Work.—The work of the adults only has proved serious. The beetles burrow into the branches and small twigs, usually in a fork or axil. The burrows or tunnels are round, from $\frac{1}{8}$ to $\frac{1}{4}$ inch in diameter and seldom more than an inch long, in living tissues. They are large enough, however, to weaken or almost completely sever the twigs. Small trees suffer most by the pruning thus received.

Distribution.—The branch and twig-borer is generally distributed throughout the State.

Food Plants.—The plants attacked are acacia, almond, apple, apricot, cherry, currant, fig, grape, coast live oak, Maul oak, olive, orange, peach, pear and prune.

Control.—Control measures are very difficult and from a financial point of view are out of the question, as the damage done would not warrant the cost of adequate remedies.

THE TRICOLORED XYLOPERTHA

Xylopertha suturale (Horn)¹⁴² (Family Bostrychidae)

(*Sinoryglon suturale* Horn)

(Fig. 228)

Description.—The beetles are nearly cylindrical in shape, about $\frac{1}{8}$ inch long; head and abdomen, black; prothorax and posterior half of wing covers, dark red-dish-brown, and the antennæ, legs and anterior half of the wing covers, light amber.

Life History.—The adults bore into the canes and smaller twigs. The larvæ also work within the same hosts and pupate in the burrows. Adults usually continue in their tunnels during the winter and issue early in the spring.

Nature of Work.—The larvæ work near the center of grapevine canes and just beneath the bark in the twigs of trees. The adults make their burrows, which are about the size of the lead in a pencil, around the twigs, just under the bark. The small, round entrance and exit holes give evidence of the presence of the beetle.

Distribution.—This species was collected in San Diego County, February, 1914, by Mr. H. A. Weinland. It has been recorded in Los Angeles County by D. W. Coquillett¹⁴³ and H. C. Fall¹⁴⁴ and in Santa



Fig. 228.—The tricolored *Xylopertha*, *Xylopertha suturale* (Horn). Beetles and their work on acacia. Slightly enlarged. Specimens collected at San Diego by H. A. Weinland. (Original)

¹⁴²A uniformly brown species, *Xylopertha declive* (Lec.), is more abundant than the above. It attacks acacia, California laurel, eucalyptus and oak. It also bores through the lead casings of telephone wires.

¹⁴³Insect Life IV, p. 261, 1892.

¹⁴⁴Cal. Acad. Sci. VIII, p. 133, 1901.

Barbara County and the northern part of the State by Dr. Edwin C. Van Dyke.

Food Plants.—Dr. E. C. Van Dyke records coast live oak as the normal host plant, H. A. Weinland found large numbers of acacia trees infested and D. W. Coquillett bred adults from dead grapevine canes. Living and dead tissues are attacked.

Control.—Cutting out and burning the infested branches as soon as the work is observed in January and February is the best means of control. This is to be recommended only for small gardens or parks, and not for woodlands or wild areas.

SCARABÆIDÆ (Family)

LEAF-CHAFERS, COCK CHAFERS, JUNE BEETLES, SCAVENGER BEETLES,
TUMBLE BUGS

This is a large family of beetles which vary greatly in size, color and habits. All are characterized by having the antennæ elbowed and

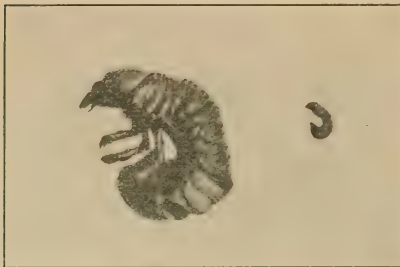


Fig. 229.—White grubs, the larvæ of beetles belonging to the family *Scarabæidæ*. Natural size. (Original)

terminating in an enlarged segmented club, the segments of which may be fixed, transverse teeth or folded together so as to open and close like the leaves of a book. The tarsi are five-jointed. Nearly all of the adults of the familiar types of the lamellicorn leaf-chafers, cock chafers and June beetles feed upon vegetation and the larvæ, known as "white grubs," live underground and feed upon the roots of plants.

The scavenger beetles or

tumble bugs and dung beetles live upon dung and are of no economic importance. A few other members, known as skin-beetles, feed upon decaying animal skins, hoofs, etc.

THE SOCIAL SCARABÆID

Cænonycha socialis Horn

(Fig. 230)

Description.—The beetles are light brown with the prothorax and head dark amber-brown. Some individuals are dark amber-brown throughout. The average length is $\frac{3}{8}$ inch and the width half as much.

Life History.—The life habits are unknown. In all probability the larvæ live in the ground and feed upon the roots of plants. The adults appear in April and often in sufficient numbers to destroy considerable foliage. Their attacks are usually of short duration.

Nature of Work.—The leaves or portions thereof are devoured by the adults.

Distribution.—Large numbers of the beetles were collected in Kern County, April 14, 1914, by K. S. Knowlton, county horticultural commissioner. H. C. Fall records it from San Diego County.¹⁴⁵

Food Plants.—The foliage of apricot and plums was attacked in Kern County. The native hosts are unknown.

Control.—As the attacks are of short duration, usually one application of a poison spray when the beetles appear will suffice to save the foliage of the trees. Four pounds of neutral arsenate of lead to fifty gallons of water may be used.



Fig. 230.—The social scarabæid, *Carnonycha socialis* Horn. Enlarged twice. Specimens collected at Bakersfield by K. S. Knowlton. (Original)

THE GRAPEVINE HOPLIA

Hoplia callipyge Leconte¹⁴⁶

(Fig. 231)

Description.—The adults vary from $\frac{5}{16}$ to $\frac{3}{8}$ inch in length. The ground color is light brown, though an occasional specimen is much darker. On the dorsum are arranged, in mottled effect, light colored scales, which are easily rubbed off. The ventral surface is covered with beautiful silvery scales, showing many iridescent colors in bright light. The whole body is covered with quite long fine white silky hair. The eggs are pearly white.

Life History.—The life history of this beetle has not been worked out, but it probably resembles that of the other chafers. The glossy, white eggs are laid in old pastures. The grubs feed upon the roots and grow very slowly, requiring from one to two years to become full-grown. They remain in the larval or pupal stage throughout the winter and emerge as adult beetles early in the spring and attack many kinds of vegetation.

Distribution.—This beetle seems to be most abundant in the San Joaquin Valley, and more particularly in the southern part. It is also found in the southern part of the State.

Food Plants.—The usual food appears to be the young buds and older foliage of rose bushes, which often suffer greatly from the attacks.

¹⁴⁵Proc. Cal. Acad. Sci., VIII, p. 140, 1901.

¹⁴⁶Key to California species of *Hoplia*:

- a. Scales on the dorsum light or grayish----- b.
- Scales on the dorsum brightly colored----- *dispar* Lec.
- b. Hair short and stiff and longer on the dorsum of prothorax than on the elytra----- c.
- Hair rather long and silky and of about the same length over the entire dorsum----- *callipyge* Lec.
- c. Hair on elytra exceedingly short and inconspicuous; little or no hair on pygidium----- *sackenti* Lcc.
- Hair on elytra quite abundant; thick long hair on pygidium----- *pubicollis* Lec.

As early as 1893¹⁴⁷ it was known to do considerable damage to the buds and leaves of grapevines. Occasionally large areas of vineyards are completely stripped. During the last two years considerable damage has been done in the San Joaquin Valley. It also feeds upon greasewood.¹⁴⁸



Fig. 231.—The grapevine *Hoplia*, *Hoplia callipyge* Lec. Adults feeding on a rose. Slightly enlarged. (Original)

beetles into a suitable receptacle containing oil may also prove effective, especially if only small areas are badly infested.

Control.—The larval and pupal forms are found in the soil, probably in unplowed pastures and places around fences, ditches, etc. Thorough cultivation of these places may not only kill the young then present, but will keep the adults from laying eggs there. Poison sprays applied when the beetles begin to appear in considerable numbers and repeated every week will aid materially in saving the buds and foliage. Jarring the

THE BEAUTIFUL HOPLIA

Hoplia dispar Leconte

Description.—The adults are exceedingly pretty, because of their bright colored scales. The ground color is black, but the entire dorsum or only portions thereof may be covered with brown, yellowish brown, orange yellow and olive or pale green scales. If the scales are rubbed off the black ground color shows through. The ventral surface is covered with iridescent silvery scales. The hair on the dorsum is short and sparse. The length varies from $\frac{1}{4}$ inch for the males to nearly $\frac{1}{2}$ inch for the females.

Life History.—The life history is practically the same as that of *Hoplia callipyge* Lec.

Nature of Work.—The adults eat holes in foliage and blossoms of the food plants.

¹⁴⁷Insect Life, V, pp. 343-344, 1893.

¹⁴⁸Fall, H. C., Proc. Cal. Acad. Sci., VIII, p. 139, 1901.

Distribution.—This species is apparently confined to the Sierra foothills of the central and northern parts of the State.

Food Plants.—Rosaceous plants comprise the normal food. Dr. Van Dyke has observed it to be a serious pest to roses and *Ceanothus* in the high Sierras.

Control.—Control measures are the same as for *Hoplia callipyge* Lec.

THE PUBESCENT HOPLIA

Hoplia pubicollis Leconte

(Fig. 232)

Description.—The ground color of the dorsum is light brown and that of the prothorax and head often darker, but not so dark as in *H. sackenii*. Light colored scales are arranged on the elytra to give a mottled effect. The ventral surface is covered with silvery scales. This species is distinguished from the rest by having comparatively long hair on the head and prothorax and shorter hair on the elytra. The length varies from $\frac{1}{4}$ inch to $\frac{3}{8}$ inch. It most resembles *H. callipyge* in size and color and may be distinguished by the length of hair on the dorsum of the elytra and prothorax, and by being more elongated in shape.

Life History.—Adults issue in April and May and begin feeding, often in great numbers, upon the buds, blossoms and leaves. When disturbed they drop to the ground and bury themselves. Like most beetles of this family, they feed principally by night, but also work in the daytime, especially in cloudy weather.

Nature of Work.—The buds and blossoms seem to be preferred and are either entirely destroyed or the pistils and stamens are devoured. The leaves are also eaten and appear very ragged.

Distribution.—This species is quite abundant in the Sierra foothills, but is also more or less common in the lower Sacramento and San Joaquin valleys and in the southern part of the State. It is the most common species in the State, especially in the lowlands.

Food Plants.—Blackberries, wild and cultivated, are sometimes seriously injured by this beetle. The writer collected great numbers of this species in the Yosemite Valley, where they were feeding upon the flowers of azalea (*Rhododendron occidentale*) and yarrow (*Achillea millefolium*).

Control.—Control measures are the same as recommended for *Hoplia callipyge* Lec.



Fig. 232.—The pubescent Hoplia, *Hoplia pubicollis* Lec. Adults on blackberry. Natural size. Specimens taken at Placerville by J. E. Hassler. (Original)

SACKEN'S HOPLIA

Hoplia sackenii Leconte

Description.—The ground color of the beetles is a decided brown with light scales upon the dorsum, giving a grayish appearance. The head and prothorax are bluish-black and covered with long, fine whitish hair. The hair on the elytra is much shorter. The ventral surface is metallic silver. The average length is $\frac{3}{8}$ inch.

Life History.—The life history is practically the same as for *Hoplia callipyge* Lec.

Distribution.—This species is only distributed throughout the high Sierras, having been received by the writer from Siskiyou and Placer counties and reported in the San Joaquin Valley,¹⁴⁹ and from San Diego County.¹⁵⁰

Food Plants.—The foliage of grape¹⁴⁹ is the only recorded food.

Control.—Control measures are the same as for *Hoplia callipyge* Lec.

THE CALIFORNIA LACHNOSTERNA

Lachnosterna errans Leconte¹⁵¹

(Fig. 233)

Description.—The beetle is rich dark brown above, yellowish-brown beneath and averages about $\frac{3}{4}$ inch in length. The grub is yellowish-white with brown head and black jaws. It is covered with fine brown hairs. The average length is $1\frac{1}{4}$ inches and the width $\frac{1}{4}$ inch. Both the mature and immature forms greatly resemble the June beetle, *Lachnosterna fusca* (Fro.), of the Eastern States.

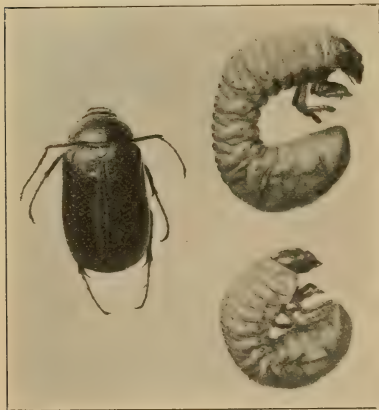


Fig. 233.—The California *Lachnosterna*, *Lachnosterna errans* Lec. Adult and grubs, enlarged one half. (Original)

Life History.—The life history of this species has never been worked out, but is probably as follows: the insect hibernates in the adult or larval stage and adults appear early in the spring (April and May), often swarming in great numbers around lights and feeding at night upon the foliage of trees, and hiding usually underground during the day. The females deposit their

eggs in the spring, two or three inches under the surface of the soil. These hatch into the white grubs, which feed upon the roots of grasses

¹⁴⁹Insect Life, VII, p. 368, 1895.

¹⁵⁰Fall, H. C., Proc. Cal. Acad. Sci., VIII, p. 139, 1901.

¹⁵¹*Lachnosterna fusca* (Fro.) is reported as occurring very rarely in California.

and other plants during the remainder of the summer and remain in the soil in a dormant condition during the first winter and begin to feed upon the roots again the following spring and summer. They transform into pupæ the fall of the second year. The adults emerge in September and October. Thus two years are required for the larval stage and one year for the completion of the adult stage. Mr. J. J. Davis has found considerable variations in the life history of the *Lachnosterna* beetles, and the above may not at all fit the California species, but it will serve to give a general idea of the development.

Nature of Work.—The larvæ destroy the roots of plants underground and the adults feed upon the foliage, usually eating ragged holes in the leaves.

Distribution.—This species is limited to the middle and northern parts of the State.

Food Plants.—The grubs have been reported as doing much damage to lawns. They also feed upon the roots of various other grasses. The adults attack the leaves of fruit trees, ornamentals and native shrubbery.

Control.—The control of this pest is rather difficult, due to the fact that the grubs live in the soil and are difficult to kill. Sod lands are excellent breeding places, and when first plowed should be planted to some crop which the grubs do not readily attack, as clover and potatoes. Fall plowing is also recommended. In lawns, carbon bisulfid may be applied with deadly effect to the grubs if the soil is fairly loose but not too sandy. About a teaspoonful to every two or three square feet should be used.

THE MUCK OR CARROT BEETLE

Ligyris gibbosus DeGeer

(Fig. 234)

Description.—The beetles greatly resemble the California *Lachnosterna*, being robust, dark reddish-brown throughout, but with a distinct short horn on the front of the head, which readily separates it from the former. They average from $\frac{1}{2}$ to $\frac{5}{8}$ inch in length.

Life History.—The adults begin to appear early in the spring (April and May) and are common until winter, when they go into hibernation. The damage is done by the adults, which bury themselves in the ground and eat off the roots of plants just below the surface. The larvæ are white grubs and live upon the roots of plants in the soil. In general habits they resemble the common Eastern June beetle, *Lachnosterna fusca* (Fro.), and appear to be responsible for much damage to crops in this State.

Nature of Work.—The adults cut off the roots of the food plants beneath the surface of the soil, in much the same manner as cutworms.



Fig. 234.—The muck or carrot beetle, *Ligyris gibbosus* DeGeer. Adult, enlarged twice. (Original)

Distribution.—This is a very common beetle throughout the entire State, but is rare in the San Francisco Bay region.

Food Plants.—The exact status of the feeding habits of the grubs is so confused with that of the grubs of the June beetles that it is impossible to give a list of host plants. It is believed, however, that the roots of grasses and wild plants as well as a great many cultivated plants are injured. The adults are reported as feeding upon the roots of carrots, beets, etc., and upon the foliage of oak and elm trees.

Control.—Control measures are the same as for the California *lachnosterna*. Real profitable control measures are out of the question where large fields are infested.

THE HAIRY PHOBETUS

Phobetus comatus Leconte

(Fig. 235)

Description.—The beetles are usually light amber-brown with the elytra, abdomen and head somewhat darker. The prothorax is very light yellow with a brown spot on each side. The coxæ and femora of the legs are light, while the tibiae and tarsi are dusky. The dorsum of the prothorax is clothed with short fine yellow hairs and the ventral surface of the entire thorax is covered with similar hairs, which are much longer. The hair on the abdomen and legs is of the same color, but not so long or thick. The antennæ are short and small. The beetles average $\frac{9}{16}$ inch in length and $\frac{5}{16}$ inch in width.



Fig. 235. — The hairy Phobetus, *Phobetus comatus* Lec. Dorsal and ventral views of adults. Enlarged one third. Specimens taken at Auburn by H. H. Bowman. (Original)

continue through the day. Those feeding by night bury themselves in the ground near the bases of the trees during the day. The larval stage is unknown, but the grubs probably live in the ground and feed upon the roots of wild grasses and other plants.

Nature of Work.—The beetles devour the leaves. The work of the larvæ is unknown.

Distribution.—Numbers of the beetles were collected in Placer County, April 27, 1914, by Horticultural Commissioner H. H. Bowman. Fall¹⁵² records it from Catalina Island and from San Diego and Los Angeles counties and the San Joaquin Valley. It is, therefore, quite generally distributed throughout the State.

¹⁵²Fall, H. C., Proc. Cal. Acad. Sci., VIII, p. 141, 1901.

Food Plants.—The foliage of various fruit trees, including apple, pear, peach, is devoured by the adults.

Control.—This insect is not likely to do more than occasional damage, when it may be controlled by the application of a poison spray.

THE WHITE-LINED SCARABÆID

Polyphylla crinita Leconte¹⁵³

(Figs. 236, 237)

Description.—This beetle is familiar to nearly everyone, because of its abundance, and may be easily recognized by the illustration, Fig. 236. The general color is rich brown. The dorsum is covered with fine white scales, which are thickly arranged in definite areas, so as to appear as white longitudinal lines on the dorsum and as transverse lines on the ventral surface of the abdomen. The under surface of the head and thorax and the bases of the legs are thickly clothed with fine, long, brown hairs. There are also quite long brown hairs on the dorsum of the head and prothorax. The length averages about 1 inch. The grub is very large, cream or white and clothed with reddish-brown hairs. It attains a length of nearly 2 inches.

Life History.—The life history of this beetle is not well known, but probably differs little from that of the California *Lachnosterna*, *Lachnosterna errans* Lec. The grubs occasionally attack the roots of trees, especially in sandy places along the margins of streams and the seashore.

Nature of Work.—The normal work of the adults and grubs on native plants has not been observed by the writer, but grubs were found to entirely cut off the roots of young trees and to eat out small round holes in the bark, as shown in Fig. 237.



Fig. 236.—The white-lined scarabæid, *Polyphylla crinita* Lec. Adult male, enlarged twice. (Original)

¹⁵³A closely allied species, *Polyphylla decemlineata* Say, greatly resembles this beetle, but lacks the long hairs on the dorsum of the head and prothorax. It is common throughout the State and most abundant in the southern and eastern parts.

Distribution.—This beetle is generally distributed throughout the State, but is most abundant in the northern part.



Fig. 237.—The larva of the white-lined scarabæid, *Polyphylla crinita* Lec., and its work upon the roots of a young pear tree. Slightly reduced. (Original)

Food Plants.—The native food plants are not known to the writer; however the grubs were noted attacking the roots of young pear trees to a considerable extent in Nevada County.

Control.—This beetle is rarely injurious, and then not enough so as to warrant the cost of control measures.

THE FRUIT-TREE SERICAS

Serica alternata Leconte*Serica anthracina* Leconte*Serica fimbriata* Leconte*Serica mixta* Leconte

(Figs. 238, 239)

Description.—The first two species are light amber or brown with a silvery bloom on the dorsum. *Serica alternata* Lec. is about $\frac{1}{4}$ inch long, while *S. fimbriata* Lec., the largest of the four, is $\frac{3}{8}$ inch long. The manzanita Serica, *S. anthracina*, is about $\frac{1}{4}$ inch long and varies from light brown to almost black. The last species, *S. mixta* Lec., is dark brown and about the same size as *S. alternata* Lec. Figs. 238 and 239 show the general characters very well.



Fig. 238.—*Serica alternata* Lec. and the nature of its work on prune leaves. Slightly enlarged. Specimens received from R. S. Vaile, Ventura. (Original)

Life History.—In a general way, the life history resembles that of the California *Lachnosterna*. The grubs live upon the roots of plants in the soil. The adults feed largely by night and hide during the day.

Nature of Work.—The adults are leaf-eaters, preferring usually the tender shoots. Fig. 238 shows the character of their work.

Distribution.—*Serica alternata*, *S. fimbriata* and *S. mixta* are common in the southern part of the State, while the latter is also abundant in the central part, especially in the valleys. The manzanita *Serica*, *S. anthracina*, is confined almost entirely to the Sierra foothills and higher altitudes.

Food Plants.—The foliage of many cultivated ornamental and fruit trees are attacked, including apple, apricot, plum, prune, etc. The manzanita *Serica* normally feeds upon manzanita and black oak.

Control.—Control measures are very difficult and usually too expensive for the commercial orchardists. Poison sprays, applied as soon as the damage is noticed, will give temporary relief.

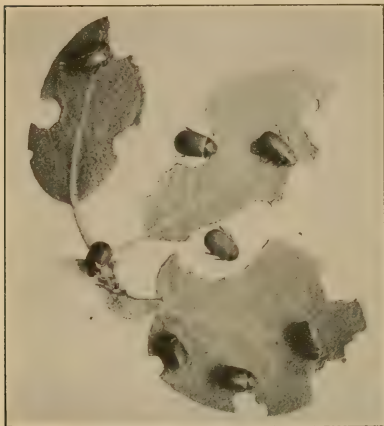


Fig. 239.—The manzanita *Serica*, *Serica anthracina* Lec. Adults and their work on manzanita, which looks very much like their work on fruit trees. Natural size. Specimens collected at Redding by Leroy Childs. (Original)

CERAMBYCIDÆ (Family)

LONG-HORNED BEETLES OR CERAMBYCIDS

This is a large family of very familiar beetles characterized by the elongated bodies and the slender antennæ which are often longer than the body. The tarsi are four-jointed. The larvæ are wood borers, as



Fig. 240.—The California laurel borer, *Rosalia funebris* Mots., a light blue and black long-horned beetle common throughout the state. The larvæ live in the California laurel. Enlarged twice. (Original)

are also many of the adults. The members are generally very destructive and, though primarily forest pests, often do much damage to orchard and ornamental trees.

THE CALIFORNIA PRIONUS

Prionus californicus Motschulsky¹⁵⁴

(Fig. 241)

Description.—The beetles are dark brown and quite large, varying from 1 to 1½ inches in length. There are several large, sharp teeth or spines on the lateral margins of the prothorax. The antennæ are twelve-jointed. The larvæ are exceedingly large, often attaining a length of 2½ inches. They are white or yellowish, with a small reddish or dark brown head.

Life History.—The complete habits of this species are very imperfectly known. The adults do not appear until July and August, the winter being spent in the larval stage. The larvæ begin to appear in the fall and work in the trunks and roots of the trees, often doing considerable damage. The running sap usually serves as a means of

¹⁵⁴The broad-necked borer, *Prionus laticollis* Drury, included in the first edition, does not occur in this State according to Prof. H. C. Fall and Dr. E. C. Van Dyke. All references to it in California probably refer to the California Prionus.

finding the burrows in the trunks, but only the dying tree will disclose the injury to the roots. Pupation takes place in early summer.

Nature of Work.—The larvæ destroy the roots by completely hollowing them out. They also make large burrows in the trunks, from which the sap may or may not flow. Young trees are often completely killed by their attacks.



Fig. 241.—The California Prionus, *Prionus californicus* Mots. Adults enlarged twice. (Original)

Distribution.—This species is widely distributed throughout the State and is exceedingly common.

Food Plants.—The following plants are attacked: apple, blackberry, chestnut, grape, oak, poplar, prune and black and English walnut.

Control.—Probably the best method is to dig out the larvæ or kill them in the burrows with a wire. Control measures, however, are seldom if ever necessary for this beetle.

THE SPOTTED TREE-BORER

Synaphata guerci Leconte

(Fig. 242.)

Description.—The beetles are bluish-gray with black markings and spots, as shown in Fig. 242. The dorsum, especially around the margins of the black areas, are marked with orange-yellow. The antennæ are longer than the body and the bases of all the joints except the first two are light blue. The legs are marked with light blue and black and spotted with orange and black. The inside of the first three tarsi

of all the legs are clothed with short orange-colored hair. The average length is about $\frac{7}{8}$ inch and the greatest width $\frac{3}{8}$ inch.

Life History.—The life history is probably parallel to that of the nautical borer. The insect has not been studied more than to rear it from injured or dead trees. They breed year after year in the heartwood.

Nature of Work.—The larvæ usually feed upon dead or dying trees, but not infrequently they attack living tissues and do some injury.

Distribution.—This beetle ranges from British Columbia to the southern part of California.

Food Plants.—The normal food plants are California buckeye¹⁵⁵ and cottonwood and probably the wild walnut, inasmuch as the cultivated English walnut is sometimes seriously injured.

Control.—The measures recommended for such beetles as the flat-headed apple-tree borer and the oak twig-girdler may be used to control this pest. In practically all cases control measures cost more than the actual damage done.



Fig. 242.—The spotted tree-borer, *Synantharta gueri* Lec. Adult, natural size. (Original)



Fig. 243.—*Xylocrius cribratus* Lec. A black beetle injuring gooseberries in California. Enlarged twice. (Original)

THE BLACK GOOSEBERRY BORER

Xylocrius agassizii Leconte¹⁵⁶

(Fig. 243)

Description.—The beetles are dull black, sparsely covered with hair and about $\frac{1}{2}$ inch long. They greatly resemble *X. cribratus* Lec. (Fig. 243), but the apical portions of the elytra are smoother on the surface.

Life History.—The larvæ work within the stems of the gooseberry bushes. They enter at a fork or axil and work down towards the roots, where the winter is spent. There is usually but one in a bush.¹⁵⁷

Nature of Work.—The injury is caused by the burrows of the larvæ in the stems and the bases of the roots, often resulting in death to parts or to whole bushes.

¹⁵⁵Fall, H. C., Rept. Cal. Acad. Sci., VIII, p. 150, 1901.

¹⁵⁶A closely related species, *Xylocrius cribratus* Lec., is also reported by Dr. E. C. Van Dyke as injurious to gooseberries in California. It is the most abundant of the two and is distinguished from the above species by having the posterior portion of the elytra more punctured and therefore rougher. (Fig. 243).

¹⁵⁷Bul. No. 23, n. s. Bur. Ent., U. S. Dept. Agric., pp. 90-91, 1900.

Distribution.—The beetle occurs in the middle and northern Sierra Mountains.¹⁵⁸

Food Plants.—Cultivated gooseberry bushes have been recorded as hosts, but as the insect is native no doubt wild gooseberry and probably other related plants are also attacked.

Control.—Cut out and burn the infested canes when the damage is severe enough to warrant control measures.

THE NAUTICAL BORER

Xyloterchus nauticus Mannerheim

(Figs. 244, 245)

Description.—The beetles are slender with noticeably long legs and rather short antennae. The color is dark with irregular light broken bands on the elytra, as shown in Fig. 245. The body is entirely covered with fine white hair, giving a decidedly grayish appearance. The average length of the females is about $\frac{1}{2}$ inch. The males are slightly smaller. The larvæ are white with brown heads and mandibles. The body is slightly larger near the head and $\frac{3}{4}$ inch long. The pupæ are yellow or white and slightly over $\frac{1}{2}$ inch long.

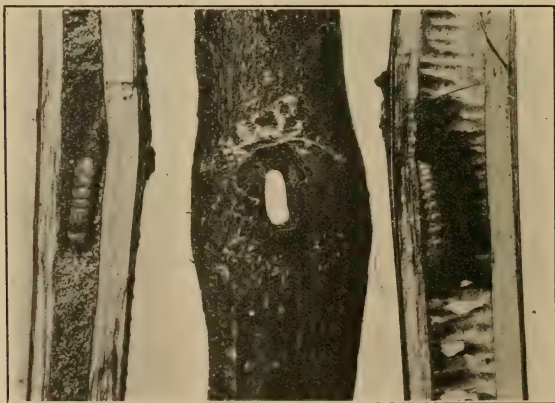


Fig. 244.—The nautical borer, *Xyloterchus nauticus* Mann. Larvæ in burrows in walnut twigs and exit hole near a bud. Natural size. Specimens received from R. S. Vaile, Ventura. (Original)

Life History.—The winter is passed in the larval stage within the burrows, where pupation takes place in April and May. The adults begin to issue the last of April. They are nocturnal and diurnal in habits. There appears to be but one brood a year.

Nature of Work.—The larvæ usually burrow into the tips of the branches, killing the twigs back for from one to several feet. They also enter the trunks and larger branches, especially if a tree is at all sickly

¹⁵⁸Fall, H. C., Proc. Cal. Acad. Sci., VIII, p. 144, 1901.

or dying. Eucalyptus logs cut for lumber are sometimes riddled with burrows made by them.¹⁵⁹

Food Plants.—During the spring of 1914 both R. S. Vaile and R. K. Bishop observed quite extensive attacks to the smaller branches of the English walnut trees. Coast live oak (*Quercus agrifolia*), wal-



Fig. 245.—The nautical borer, *Xylotrechus nauticus* Mann. Larvæ, pupæ and adult. Enlarged one and one third times. (Original)

nut and *Eucalyptus globulus* are recorded as hosts by Dr. F. E. Blaisdell.¹⁵⁹ To these hosts Dr. Van Dyke adds the peach and the author the black oak. It also attacks madrone.

Control.—Though common, the beetle has not been very serious in walnut orchards, but should it become so, the destruction of dead trees and logs, where breeding may continue, and the cutting out of infested twigs in the spring will probably prove sufficient to lessen serious injury.

CHRYSOMELIDÆ (Family)

LEAF-BEETLES OR CHRYSOMELIDS.

The members of this family are known as leaf-beetles because the larvæ and adults feed upon the leaves of plants, and chrysomelids because of the small size and beautiful golden colors of some of the species. The tarsi are four-jointed, the antennæ moderately long and the legs rather short. Many of the members have the hind femora greatly enlarged for jumping and are known as flea-beetles. A large number of species are injurious, though all feed on plants. There are many representatives in the State.

THE CALIFORNIA GRAPE ROOT-WORM

Bromius obscurus (Linnaeus)
[*Adoxus obscurus* (Linnaeus)]
(*Chrysomela obscura* Linnaeus)

(Figs. 246, 247)

Description.—The beetles are jet black or brown,¹⁶⁰ partially covered with fine whitish hairs, giving them a grayish cast, and $\frac{3}{16}$ inch long. The head and prothorax are noticeably narrower than the rest

¹⁵⁹Insect Life, V, pp. 33-34, 1892; Vol. IV, p. 262, 1891.

¹⁶⁰The light-colored form has the wing covers, tibiae and basal half of the antennæ brown, the rest of the body, black. Though only a color variation of the black form, it has been known as a separate species, *Adoxus vitis* Fourc.

of the body. The antennae and legs are usually black, but are sometimes brown instead. The eggs are elongated, yellowish-white and about 1-25 inch long. The full-grown larvæ are white with brown heads, $\frac{1}{4}$ inch long, and curved towards the ventral surface in the shape of a crescent. The pupæ are white and slightly larger than the mature beetles.



Fig. 246.—The California grape root-worm, *Bromius obscurus* (Linn.). Adults, enlarged three times. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

patches of bark removed feed underground until fall, when they become full-grown, and pass the winter in small earthen cells, transforming into pupæ in the spring and emerging as adults about two weeks later. The larvæ and pupæ are usually located within a radius of fifteen inches from the trunks, at a depth of two feet or less. The adults begin to issue about May and feed upon the foliage. They begin to lay eggs in June. There is but one brood a year.

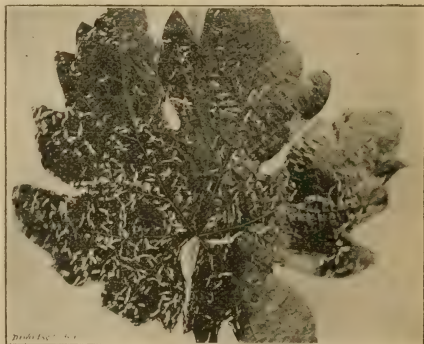


Fig. 247.—Grape leaf, showing the characteristic work of the California grape root-worm, *Bromius obscurus* (Linn.). (After Cal. Hort. Com.)

Nature of Work.—The larvæ may entirely destroy the young rootlets or patches of bark on the larger roots. The adults eat very characteristic long, narrow holes in the leaves, as shown in Fig. 247.

Distribution.—This beetle occurs throughout the northern and central parts of the State, being reported as far south as Tulare County.

Food Plants.—Apparently all varieties of grapes are attacked by this pest. The fireweed (*Epilobium angustifolium*) is, according to Dr. Van Dyke, the native host of the beetle. The leaves of *Saxifraga peltata*¹⁶¹ are also attacked.

Control.—Thorough cultivation, close to the bases of the vines, during the summer and winter will destroy many of the grubs and pupæ. The attacks of the adults may be held in check by repeated applications of arsenical sprays. Jarring them upon sticky boards or into receptacles containing oil is also recommended.

¹⁶¹Branigan, E. J., Mo. Bul. Cal. Hort. Com., II, pp. 585-586, 1913.

THE BLACK-LEGGED TORTOISE-BEETLE

Cassida nigripes Olivier

(Fig. 248)

Description.—The beetles are golden, but less brilliant than the golden tortoise beetle. The three black spots on each wing cover are larger and more conspicuous. The legs are black. The length averages $\frac{5}{16}$ inch. The larvæ are straw-yellow, with black tipped spines. There is a dusky mark along each side of the back, two dark spots just behind the head, and below these two large black crescent-shaped spots. The excrement is extended laterally in long threads or plates on the anal or fæci-fork over the back. The pupæ are dark brown with light markings. The spines are transparently white.

Life History.—In this species the eggs are laid in rows upon the stems of the plants, thus differing from most species, which deposit them singly. This accounts for the many larvæ present upon a plant, and also for the more apparent injury. The larvæ, or "peddlers," as they are called by some, feed upon the foliage.

Fig. 248.—The black-legged tortoise-beetle, *Cassida nigripes* Oliv. a and b, larvæ; c, pupa; d, adult. Enlarged three times. (After Riley)

Nature of Work.—The young and adults eat holes in and around the edges of the leaves.

Distribution.—The species is distributed throughout the State.

Food Plants.—The foliage of the sweet potato is apparently the only recorded economic host of this species, though its normal food plant is morning glory.

Control.—Remedies are the same as for the golden tortoise-beetle.

THE GREEN TORTOISE-BEETLE

Cassida pallidula Boheman(*Cassida texana* Crotch)

(Fig. 249)

Description.—The beetles are of a beautiful rich green color, with the eyes and apical portions of the antennæ black. The average length is about $\frac{3}{16}$ inch. The larvæ are light green throughout, with black anal forks.

Life History.—The beetles emerge from hibernation early in the spring and lay eggs, so that the larvæ and pupæ are present by the



Fig. 249.—The green tortoise-beetle, *Cassida pallidula* Boh. Adult, enlarged three times. (Original)

middle of May and the adults of the first generation issue the last of May and the first of June.

Nature of Work.—The larvæ and adults eat holes in and around the edges of the leaves.

Distribution.—In the southern part of the State this beetle is quite common.

Food Plants.—The larvæ and adults were observed by D. W. Coquillett to be feeding upon nightshade (*Solanum xanthii*).¹⁶² They are likely to be found upon solanaceous plants in the gardens.

Control.—Control measures are not likely to become necessary. They would be the same as for the golden tortoise-beetle.

THE GOLDEN TORTOISE-BEETLE

Coptocyclus bicolor Fabricius
(*Cassida aurichalcea* Fabricius)

(Fig. 250)

Description.—The beetles are known as “gold-bugs” and appear as drops of burnished gold, but do not have the metallic luster just after pupation or when they are dead. The color in either of these cases is a uniform golden-yellow.

There are three small black spots on each wing cover, which are prominent at first, but soon become very inconspicuous when the golden luster appears. The eggs are irregular in form, flat and narrower at one end, 1-25 inch long, of a dirty white color and are usually furnished with three spine-like projections from the posterior margin. The spines, however, may be entirely wanting. The larva or “peddler” is dark brown with pale dorsum. It carries the anal or five-fork directly over the back, which is loaded with excrement, nearly concealing the body. The arrangement of the excrement in a

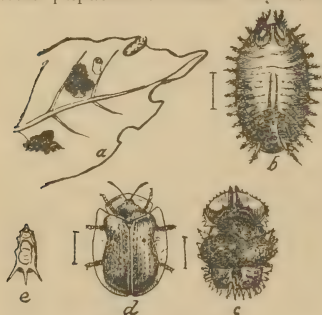


Fig. 250. — The golden tortoise-beetle, *Coptocyclus bicolor* (Fab.). a, larvæ on leaf, natural size; b, larva; c, pupa; d, adult; e, egg. b, c and d enlarged three times; e, enlarged about ten times. (After Riley)

tri-lobed pattern easily distinguishes the larvæ of this species from the others. The pupa is brown with three dark stripes on the prothorax and similar dark markings on the abdomen. In this stage the anal fork, with its load of excrement, is held close to the back.

Life History.—The eggs are laid singly upon the food plants in the spring by the over-wintering adults, and the larvæ are usually found singly and but few upon a plant. Pupation takes place where the larva has ceased feeding. There are probably several generations a year.

Distribution.—This species, though not abundant, is distributed throughout the State, being more common in the southern part.

¹⁶²Insect Life IV, p. 262, 1891.

Food Plants.—The foliage of sweet potatoes, bittersweet, morning glory and other species of *Convolvulus* are the common food plants of this species. Professor C. W. Woodworth records the columbine and cucumber as food plants.¹⁶³ The adults are often taken on citrus and other trees, but are probably only resting and not feeding upon them.

Control.—Where this beetle is a pest of sweet potatoes it is advisable to dip the tops of the young plants when they are set out in a mixture of arsenate of lead (1 pound to 10 gallons of water) and to spray the plants afterwards with this mixture, if the beetles appear after much new growth is made.

THE BLUE MILKWEED BEETLE

Chrysochus cobaltinus Leconte

(Fig. 251)

Description.—This beetle may be recognized at once by the metallic blue color which sometimes has a green iridescence. The body is smooth throughout and averages nearly $\frac{3}{8}$ inch in length. Fig. 251 shows the shape and general characters.

Life History.—

The immature stages of this beetle are not described, but the larvæ probably feed upon the roots of plants, as does a closely related species (*Chrysochus auratus* Fab.).¹⁶⁴ The adults appear in the spring of the year and feed throughout the summer.

Nature of Work.—The foliage is eaten in much the same manner as by other leaf-eating beetles.

Distribution.—The blue milkweed beetle is exceedingly common throughout the entire State.

Food Plants.—All species of milkweeds are the native and normal food plants, but the beetle occasionally attacks oleander and orchard trees. Peach trees¹⁶⁵ have been so injured. During the summer of 1914 the writer noted attacks on prune trees in the Santa Clara and Sacramento valleys.

Control.—The injury to fruit trees is so unusual as to make control measures unnecessary. Poison sprays, applied when the beetles appear,

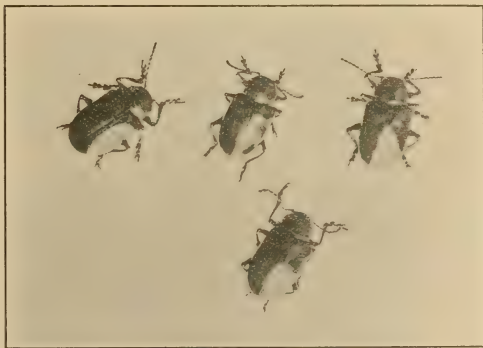


Fig. 251.—The blue milkweed beetle, *Chrysochus cobaltinus* Lec. Adults, enlarged one and two thirds times. (Original)

¹⁶³Cal. Insects, p. 216, 1913.

¹⁶⁴Insect Life III, p. 349, 1891.

¹⁶⁵Insect Life III, p. 163, 1896.

may be used to good advantage if attacks warrant the application of a remedy.

THE POTATO FLEA-BEETLE

Epitrix cucumeris Harris¹⁰⁶

(Fig. 252)

Description.—The beetles are black with pale yellowish or reddish legs and antennæ. They measure from $\frac{1}{16}$ to $\frac{1}{12}$ inch in length. When disturbed they jump very quickly. The eggs are white, elongate, with finely sculptured surface and about 1-100 inch long. The larvæ are very small and slender, white, with light brown head and prothoracic shield, $\frac{3}{16}$ inch long, and the pupæ are also white, becoming darker as they reach maturity. The apex of the abdomen is bifurcate, the forks being slender, sharp and incurved. The length is $\frac{1}{10}$ inch.



Fig. 252.—The Western flea-beetle, *Hemiglyptus basalis* Cr. Adults and their work on a turnip leaf. Enlarged three times. (Original)

Life History.—The adults hibernate under leaves, rubbish or in any sheltered place and appear early in April and May. They begin at once to feed upon such food plants as are growing at that time, often completely defoliating them, and the females deposit their minute eggs singly around the bases of the plants. The larvæ begin to hatch in May and June and live underground, feeding upon the roots and afterwards transforming into pupæ and adults in the soil. The beetles of the

¹⁰⁶The Western flea-beetle, *Hemiglyptus basalis* Cr. is about the same size as this species and dark metallic green. It is common in the Sacramento and San Joaquin valleys and attacks various cruciferous plants including cabbage, mustard, radish and turnip. The general appearance of the adults and their work is shown in Fig. 252.

second brood begin to emerge in July and August, when they become very troublesome to the foliage of plants. They are more numerous and injurious in dry hot seasons. There are two broods a year.

Nature of Work.—The beetles begin by eating small holes in the leaves. When very numerous all of the foliage excepting the larger veins and the midribs may be devoured. Fig. 252 shows well the work of an average infestation. The larvæ cut off the fine roots and sometimes eat small holes in the tubers, causing pimply potatoes, and burrow into the stalks.

Distribution.—This beetle is quite common throughout the State.

Food Plants,¹⁶⁷—Though commonly found upon solanaceous plants, the adult of this species is a very general feeder and has been reported as attacking the following plants: apple, trailing arbutus, ash, bean, beet, bilberry, cabbage, carrot, celery, wild bird cherry, clover, corn, cucumber, dogbane, eggplant, elder, ground cherry, holly, honeysuckle, hop, horse-chestnut, horse-nettle, jimson weed, lettuce, maple, muskmelon, nightshade, pepper, petunia, phlox, plantain, potato, sweet potato, evening primrose, pumpkin, radish, raspberry, rhubarb, St. John's wort, sarsaparilla, sorrel, spinach, squash, sumach, sunflower, tobacco, tomato, turnip, *Viburnum*, violet and watermelon.

Control.—Bordeaux mixture, which is so often used in controlling fungous diseases of plants, acts in a large degree as a repellent to flea-beetles. When thus used the 5-5-50 formula is recommended at the rate of 100 gallons per acre. If the flea-beetles are present in great numbers, $\frac{1}{2}$ pound of Paris green or 2 pounds of arsenate of lead should be added to the above formula of the Bordeaux mixture. Clean culture and the burning of all dead plants and rubbish during the fall of the year are valuable aids in reducing the over-wintering forms. Besides devouring the foliage, flea-beetles spread fungous diseases, especially of potatoes and tomatoes, and this alone makes it very desirable to use a combination Bordeaux mixture and arsenate of lead, as recommended above, whenever this pest becomes present in potato or tomato fields in any considerable numbers.

¹⁶⁷Johannsen, O. A.; Bul. No. 211, Me. Agrcl. Exp. Sta., pp. 43-44, 1913.

THE TOBACCO FLEA-BEETLE

Epitrix parvula Fabricius

(Figs. 253, 254)

Description.—The beetles are very small, oval, reddish-brown or light-brown and about 1-20 inch long. The wing covers are usually

marked with a broad darker transverse band across the middle. The beetles jump very quickly when disturbed. The larvæ are white with yellowish head and are about $\frac{1}{8}$ inch long.

Life History.—The adults hibernate in sheltered places and emerge to begin feeding about the time the young tobacco or tomato plants are appearing in the hotbeds. By July they are plentiful in the fields, working first upon the lower and then upon the upper leaves. The eggs are laid around the bases of the plants and the larvæ feed upon the roots and the parts of the stalks underground. It requires about a month for the first hatched young to become full-grown, pupate and emerge as adults. There are several broods a year.

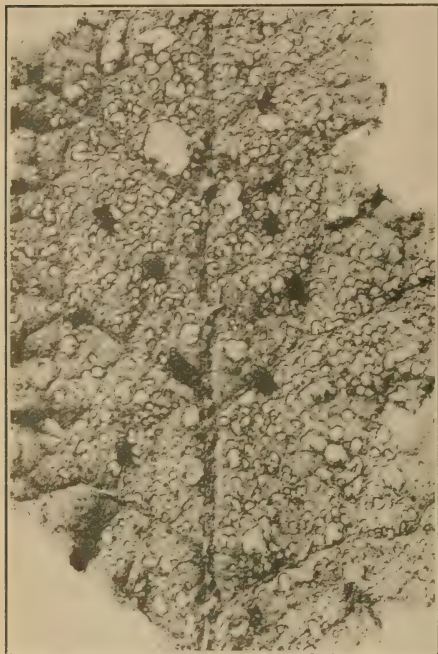


Fig. 253.—The tobacco flea-beetle, *Epitrix parvula* Fab., and its work on *Solanum marginatum*. Enlarged four times. (Original)

Nature of Work.—The beetles eat small irregular holes in the leaves of the plants and the larvæ destroy the fine roots or eat small holes in the larger roots and bases of the stalks. Both stages are usually present when the work is evident.

Distribution.—The beetle is distributed throughout the State.

Food Plants.—The recorded food plants of this species are: almond, ground cherry, horse-nettle, jimson weed, orange, pohá (*Physalis peruviana*), potato, *Solanum marginatum*, squash, tobacco and tomato.

Control.—Control measures as recommended for the potato flea-beetle are also applicable for this species. If it is undesirable to use

Bordeaux mixture, arsenate of lead alone, 4 pounds to 50 gallons of water, is recommended. If beetles are abundant, dip the plants in this solution at the time of setting. Plants should also be set out in the spring as early as possible. Seedbeds may easily be protected by covering them with cheesecloth.

THE WESTERN POTATO FLEA-BEETLE¹⁶⁵

Epitrix suberinata Leconte¹⁶⁶

(Fig. 255)

Description. — The beetles are metallic, black or dark-brown and about $\frac{1}{2}$ inch long. Like other flea-beetles, they jump quickly when disturbed. The larvæ are slender, white with brown head and about $\frac{1}{8}$ inch long. The pupæ are white and about as large as the beetles.

Life History. — According to A. L. Lovett,¹⁷⁰ who has published the life history, the adults hibernate and appear in March and April and begin feeding upon such food plants as are growing at

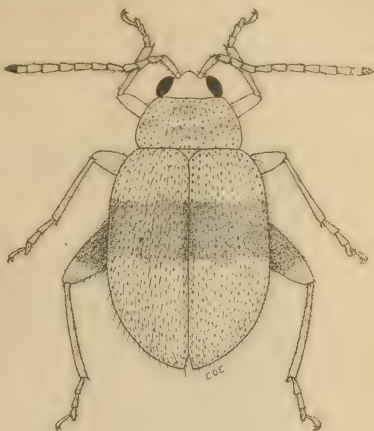


Fig. 254. — The tobacco flea-beetle, *Epitrix parvula*, Fab. Adult, greatly enlarged. (Original)



Fig. 255. — The Western potato flea-beetle, *Epitrix suberinata* Lec. Adults and their work on potato leaves. Enlarged twice. (Original)

that time. Cultivated crops become quickly infested, even before the young shoots are through the ground.¹⁷¹ The eggs are laid in the soil about the bases of the plants and hatch in June and July. The larvæ feed upon roots and tubers underground, while the adults feed usually upon the under sides of the leaves, though the upper surface does not escape their attacks. Pupæ of the first generation occur in the early part of July and the beetles begin to emerge during the latter part of the same month. These immediately begin to work upon the foliage and deposit eggs which give rise to the second

¹⁶⁵A common flea-beetle attacking the potato in various parts of the State is *Glyptina cerina* Lec. It greatly resembles the above species.

¹⁶⁶Wilson, H. F. and Lovett, A. L., *Bien. Crop Pest and Hort. Rept., Ore. Agrcl. Exp. Sta.*, p. 163, 1911-1912.

¹⁷⁰Coll. Bul. No. 19, Ext. Ser. II, No. 4, Ore. Agrcl. Exp. Sta., 1913.

¹⁷¹Insect Life, IV, p. 135, 1892.

generation, the adults of which appear in October. After a short feeding period these go into hibernation and appear early the next spring. There are two generations a year.

Nature of Work.—The adults work upon the foliage, being generally more abundant upon the under sides of the leaves. They eat small circular or irregular holes through the leaves and often attack the young plants just as they are coming up and do much damage at



Fig. 256.—*Glyptina cerina* Lec. Adults and their work on potato leaves. Enlarged one and one half times. (Original)

that time. The larvæ work underground and feed upon the roots of various plants. They also make shallow tunnels into potato tubers, causing them to appear rough and rendering them unfit for market. Most of the injury is done in July and August, when the beetles become very plentiful.

Distribution.—This beetle is apparently quite widely distributed throughout the State and Pacific Coast region.

Food Plants.—Like many of the other flea-beetles, this species is quite a general feeder, having been observed upon the following plants: potato, tomato and bean. Many other crops and weeds are also subject to attacks.

Control.—Control measures are the same as for the potato flea-beetle, *Epitrix cucumeris* Harr.

THE ALDER FLEA-BEETLE

Haltica bimarginata Say

(*Haltica alni* Harris)

(Fig. 257)

Description.—The beetles are deep metallic blue, green or purplish. The body, legs and antennæ are dark, or same as the dorsum. The fine

hair on the antennæ is whitish, while that on the tibiæ is light brown. The adults are about $\frac{1}{3}$ inch long. The larvæ are dark brown or olive green, with head and tubercles black. They are somewhat flattened and about $\frac{5}{16}$ inch long. The pupæ are white or yellow and about the same length as the adults.

Life History.—The adults hibernate and appear in the spring about the time the leaf buds begin to open and feed on the foliage upon which



Fig. 257.—The alder flea-beetle, *Haltica bimarginata* Say. Adults and the work of the larvæ and adults on alder leaf. Slightly enlarged. (Original)

the eggs are also laid. The larvæ, upon hatching, feed on the leaves and their work, combined with that of the adults, is often so severe as to nearly defoliate large trees. There are several broods a year.

Nature of Work.—In cases of an average infestation the work is well illustrated by Fig. 257. Where severe infestation occurs all of the leaf tissues excepting the larger veins are devoured.

Distribution.—This is a very common species throughout the entire State.

Food Plants.—Alder and willow are the preferred hosts, but cottonwood and poplar are also attacked.

Control.—Alder, poplar and willow trees are so often found around houses and in parks that a few suggestions on control may be welcomed by many who do not care to see the foliage ruined. The use of arsenate of lead, 4 pounds to 50 gallons of water, applied with a woodland nozzle will do much to stop the attacks of both the adult and larval forms.

THE STEEL-BLUE GRAPEVINE FLEA-BEETLE

Haltica carinata Germar¹⁷²

(Fig. 258)

Description.—The beetles are metallic bluish or purplish, with antennæ and legs black. The last ventral abdominal segment of the males has a deep elongated depression, from which is derived the specific name. The average length is slightly less than $\frac{1}{4}$ inch.



Fig. 258.—Adults of what has been called the steel-blue grapevine flea-beetle, *Haltica carinata* Germ., taken by the author at Lake Tahoe. Slightly enlarged. (Original)

Life History.—The adults emerge from hibernating quarters in the early spring and begin feeding and laying their eggs upon the vines. The eggs hatch into larvæ which work upon the leaves until fully matured, when they drop to the ground and pupate beneath the surface. The adults jump quickly or fly when disturbed.

Nature of Work.—The larvæ and adults feed upon the young buds and leaves, the buds being often entirely devoured and the leaves skeletonized.

Distribution.—This beetle is common throughout the State, being most destructive to vineyards in the southern part.

Food Plants.—The grape appears to be a favorite host of this species, but it also attacks various wild plants,¹⁷³ vegetables and elm.

Control.—Remedies, if necessary, are the same as for the California grape root-worm, *Bromius obscurus* (Linn.). Poisoned sprays are especially recommended for the flea-beetle.

THE STRAWBERRY FLEA-BEETLE

Haltica ignita Illiger¹⁷⁴

Description.—The adults are oval-oblong, bright metallic golden or bronze, with greenish or purplish iridescence. There is a large variation of colors within the species. The length is from $\frac{1}{8}$ to $\frac{1}{6}$ inch. The eggs are subcylindrical, being narrowest at the base, pale yellowish

¹⁷²Dr. G. H. Horn reported this beetle from California, but Prof. H. C. Fall thinks this an error, for he has never taken it in the State.

¹⁷³A small blue beetle, determined as this species by the late Charles Fuchs, was found plentiful feeding upon a small pink-flowered plant (*Eutheca* sp?) growing around the edges of Lake Tahoe in July, 1914. There was possibly some confusion in making the determination.

¹⁷⁴This species is very closely related to *Haltica carinata* Germ. if not the same. Prof. H. C. Fall doubts very much the existence of either species in California. The reports probably refer to closely allied native forms.

and 1-40 inch long and half as wide. They are laid in masses of from two to twenty or more and are firmly attached to the leaves. The larvæ, when newly hatched, are dirty-yellowish with large heads, but when mature they are dull yellowish or dark olive-green with black tubercles. The bodies are quite hairy. The length averages about $\frac{3}{16}$ inch and one fifth as wide. The pupæ are pale-orange with light heads and are clothed with fine short hair. There is a pair of apical hooks at the posterior end. The length is $\frac{1}{8}$ inch and the width $\frac{1}{16}$ inch.

Life History.—The eggs are laid in small masses on the leaves as soon as they appear in April and May. They hatch in about a week and the larvæ begin to feed at first almost exclusively upon the under sides of the leaves, and later upon the upper surface. They mature within two weeks and enter the ground for pupation, which requires a week or ten days. The adults hibernate. There are two or three broods a year.¹⁷⁵

Nature of Work.—The larvæ and adults feed usually upon the leaves, into which are eaten small irregular holes. They often gather in great numbers and do much damage. The buds of grapevines are also destroyed by the adults.

Distribution.—This species has been reported at Sacramento, Cal.¹⁷⁵

Food Plants.—The strawberry and grape appear to suffer most from the attacks of this beetle, but the following plants are also recorded as hosts:¹⁷⁵ calico bush (*Kalmia latifolia*), swamp laurel (*Kalmia glauca*), fire-weed (*Erechtites hieracifolius*), evening primrose (*Oenothera biennis*), Virginia creeper and peach.¹⁷⁶

Control.—Control measures are the same as for *Haltica carinata* Germ.

THE COMMON ASPARAGUS BEETLE

Crioceris asparagi Linnaeus

(Fig. 259)

Description.—The beetles are slightly less than $\frac{1}{2}$ inch in length and very slender. The color is metallic bluish-black with red thorax marked with black dots. The reddish-yellow or cream-colored wing covers are marked with black. The eggs are elongate, about $\frac{1}{10}$ inch long, dark brown or black and stuck to the shoots by one end. The larvæ are shiny, olive-gray with black heads and legs. The pupal stage is passed in the ground in thin cocoons, the pupæ being yellowish in color.

Life History.—The adults hibernate under any protective covering and appear in the spring, about the time the young asparagus shoots are coming through the ground. They immediately begin to feed upon the tender sprouts and to lay their eggs upon them. The eggs hatch in about a week and the larvæ also begin to feed upon the sprouts. The broods continue to work throughout the summer, eating all parts of the asparagus plants. About two weeks after hatching the larvæ are ready to pupate. They then leave the plant and work into the soil, where pupation takes place, and within eight or nine days they emerge as

¹⁷⁵Bul. No. 23, Bur. Ent., U. S. Dept. Agric., pp. 70-71, 1900.

¹⁷⁶Gibson, A.: Ent. Cir. No. 2, Canada Dept. Agric., p. 7, 1913.

adults. The entire life cycle requires about one month and there are many overlapping generations each year.

Nature of Work.—The young and adults feed upon the tender shoots and the older seed plants, making holes into or entirely destroying the former and destroying the foliage of the latter.

Distribution.—In the year 1904 the insect was reported as occurring at Bouldin Island, California. In 1906 it was reported to occur in great numbers at Oakley.¹⁷⁷ It is now likely to be quite widely distributed throughout the central part of the State.

Food Plant.—So far as known in this State the pest feeds only upon asparagus, attacking principally the tender shoots, but also working upon the skin and stems of the older seed plants.

Control.—The control of this beetle is not so difficult as it would seem, in view of the fact that arsenical sprays cannot be used upon the tender marketable shoots, because of the poisonous effects to the consumers.

In the spring, when harvesting the shoots, it is advisable to leave some of them for the beetles to lay their eggs upon, cutting and burning these before the eggs hatch. Another practice is to keep all the seed-



Fig. 259.—The common asparagus beetle, *Crioceris asparagi* Linn. *a*, adult; *b*, egg on leaf; *c*, newly hatched larva; *d*, full-grown larva; *e*, pupa; *f*, eggs attached to the plant. *a-e*, greatly enlarged; *f*, slightly reduced. (After Chittenden, U. S. Dept. Agric.)

lings, except a few for traps, cut down. Upon those left the beetles will collect in great numbers and may be easily killed. In the spring, or after they are covered with eggs, the plants should be cut down and burned.

As soon as the crop is harvested the seedlings and feathery plants should be thoroughly sprayed with arsenical sprays, which will serve to kill many of the mature beetles before they go into winter quarters. One pound of lead arsenate to 16 gallons of water has given excellent results.

Dusting air-slaked lime or pyrethrum upon the larvæ and spraying infested plants with kerosene emulsion or tobacco extract and soap (Black Leaf "40" 1 gallon, whale oil soap, 4 pounds, water 500 gallons) are exceedingly effective in killing the delicate larvæ. Brushing to the

¹⁷⁷Chittenden, F. H., Cir. No. 102, Bur. Ent., U. S. Dept. Agric., p. 4, 1908.

ground also destroys large numbers of them. Burning old stalks and rubbish during the winter will eliminate many of the hibernating adults.

Natural Enemies.—The young of the ladybird beetles, *Megilla maculata fuscilabris* and *Hippodamia convergens*, prey upon the young larvæ. In the East the spined soldier-bug (*Podisus maculiventris* Say) and the bordered soldier-bug (*Stiretrus anchorago* Fab.), as well as certain other insects, also feed upon the larvæ.

THE RED AND YELLOW LEAF-BEETLE

Cryptocephalus castaneus Leconte

(Fig. 260)

Description.—The beetles are short and robust, some specimens being almost cylindrical in shape and $\frac{3}{16}$ inch long. They are dull red with bright yellow longitudinal stripes on the prothorax and yellow markings on the head, elytra and under side of the body. The legs and antennæ are reddish, the latter being very slender and nearly as long as the body.

Life History.—The life history is not known. The beetles appear upon the plants during the early spring, where they continue to feed throughout the summer.

Nature of Work.—The adults eat small holes in the foliage of the host plants.

Distribution.—The species occurs throughout the State and is specially common in the interior valleys.

Food Plants.—The writer has taken the beetles from the following plants: wild and cultivated blackberries and roses and wild liquorice. The normal food plant is the willow, according to Dr. Van Dyke.

Control.—As the beetles drop from the plants if only slightly disturbed, they are easily captured on sheets or upon tanglefoot paper by jarring. Evening appears to be the best time to do this.



Fig. 260.—The red and yellow leaf-beetle, *Cryptocephalus castaneus* Lec. Adults, enlarged nearly three times. (Original)

THE WESTERN TWELVE-SPOTTED CUCUMBER BEETLE

Diabrotica soror Leconte¹⁷⁸

(Fig. 261)

Description.—This beetle is easily recognized by its bright green wing covers, which are spotted with black, as shown in Fig. 261. The prothorax is green or yellowish, the head, antennæ, legs and body black.



Fig. 261.—The Western twelve-spotted cucumber beetle, *Diabrotica soror* Lec. Adults and their work on watermelon leaf. Slightly enlarged. (Original)

The average length of the females is nearly $\frac{1}{4}$ inch; the males are somewhat smaller. The eggs are dull yellow, elongated, with one end slightly larger, finely sculptured surface and about 1-38 inch long. The larvæ are white with yellowish or brownish head and about 1 inch long when full-grown. The pupæ are white or yellowish until nearly ready to transform into adults, when they gradually assume the color of the latter.

Life History.¹⁸⁰

Many of the adults hibernate and begin feeding early in the spring, when egg-laying begins (March to May). The eggs are laid singly or in masses of from four

or five to fifty about the bases of food plants, from $\frac{1}{4}$ to $\frac{1}{2}$ inch below the surface of the ground. The larvæ feed upon the roots. When full-grown they form earthen pupal cells near the surface of the ground, where pupation takes place, and in about two weeks the adults emerge. There are probably at least two broods a year.

¹⁷⁸Key to California species of *Diabrotica*.

- a. Wing covers or elytra green with black spots..... b.
- Wing covers or elytra light yellow with three black longitudinal stripes..... *trivittata* Mann.
- b. Under side of body light yellowish or greenish, at least portions of legs and antennæ light..... c.
- Body, legs and antennæ black throughout..... *soror* Lec.
- c. Black spots on elytra pronounced and fairly constant; first 3 articles of antennæ and bases of femora light; remainder black..... *12-punctata* Oliv.¹⁷⁹
- Black spots on elytra indistinct, exceedingly variable or often entirely obliterated, entire legs and antennæ yellow, green or light brown..... *12-punctata tenella* Lec.

¹⁷⁹This species does not occur in this State, according to Dr. Van Dyke. All records regarding it refer to other species.

¹⁸⁰Chittenden, F. H., Bul. No. 82, Pt. VI, Bur. Ent. U. S. Dept. Agric., pp. 71-75, 1910.

Nature of Work.—The adults are leaf eaters and their work is easily recognized by the fact that the beetles are usually to be found where the damage is done. Occasionally only the epidermis of the leaves is devoured, but more often holes are eaten through and irregular portions around the edges or the entire leaves are devoured. Buds and open flowers are also injured in the same manner. The work of the larvæ is more difficult to ascertain and requires a close examination of the roots of dead or dying plants to find the grubs at work. They eat the roots from the outside and do not bore into them, as does the Eastern species (*D. 12-punctata*).¹⁸⁰

Distribution.—This is an exceedingly common beetle throughout the entire State.

Food Plants.—This species is a very general feeder, the adults having been observed eating the foliage of the following plants: alfalfa, bean, clover, beets, citron, cucumbers, cabbage, squash, muskmelon, watermelon, corn, peas, peanut, potato, spinach, lettuce, lemon, mustard, apricot, orange, prune, weeds and many other plants. The buds and flowers of the rose, chrysanthemum, daisy, aster, zinnia and other ornamentals are also often seriously injured or entirely destroyed. The larvæ also work upon the roots of many plants and have been observed upon the following: peanut, pea, alfalfa and beet. Nearly every year the beetle has proven to be quite a serious pest in one or more localities in the State.

Control.—When necessary, control measures must be applied with promptness and thoroughness to prevent loss. Arsenate of lead (neutral preferred, because it does not burn foliage) at the rate of from 6 to 10 pounds to 100 gallons of water and a combination spray of arsenate of lead and Bordeaux mixture (6 pounds of arsenate of lead to 100 gallons of Bordeaux mixture) have each given good results, as reported by H. O. Marsh.¹⁸¹

Natural Enemies.—The two common natural enemies of this beetle are the tachina fly, *Celatoria diabrotica* Shim.,¹⁸² the maggots of which live within and destroy the adult beetles, and a spider, *Xysticus gulosus* Keys.¹⁸³

THE TWELVE-SPOTTED CUCUMBER BEETLE OR SOUTHERN CORN ROOT-WORM

Diabrotica 12-punctata Olivier¹⁸⁴

(Fig. 262)

Description.—The adults of this species greatly resemble the Western species (*D. soror*), but are somewhat larger, a little paler green in color, with the twelve black spots on the elytra distinctly separated and seldom run together, as often occurs in the markings of the latter. The head is black and the body light green or yellow. The first three joints of the antennæ and the bases of the femora are yellow, the remainder being very dark or black. The eggs are pale yellow, oval,

¹⁸⁰Chittenden, F. H., Bul. No. 82, Pt. VI, Bur. Ent. U. S. Dept. Agric., pp. 71-75, 1910.

¹⁸¹Bul. No. 82, Pt. VI, U. S. Dept. Agric., pp. 81-82, 1910.

¹⁸²Coquillett, D. W., Insect Life II, pp. 233-236, 1890.

¹⁸³Coquillett, D. W., Insect Life II, p. 74, 1889.

¹⁸⁴This species does not occur in the State, according to Dr. Van Dyke.

with finely sculptured surface and about 1-40 inch long.¹⁸⁵ The larvæ are white or pale-yellow with brown head and the tip of tail gray. When full-grown they are from 1 to 1½ inches long. The pupæ are first white, becoming dark as they mature.

Life History.—In general the life history of this species is the same as that of *D. soror*. The adults hibernate, emerge in the spring and begin egg-laying in March, April and May. The eggs are deposited in small masses about the bases of the food plants, just under the surface of the soil, and hatch within a week or ten days. The larvæ feed upon roots, boring tunnels into them, and become full-grown in about one month. The pupal cells are made near the surface of the ground and within about two weeks the adults emerge. There are at least two broods a year, with an indication of a third.



Fig. 262.—The twelve-spotted cucumber beetle, *Diabrotica 12-punctata* Oliv. Adult, greatly enlarged. (Original)

Nature of Work.—The adults feed upon foliage, buds and flowers of many plants, riddling them with holes and producing sickly, ragged and unsightly plants. As the larvæ tunnel into the roots or bases of plants under the ground, the injuries are less easy to locate.

Food Plants.—While this beetle is an omnivorous feeder, certain plants are apparently preferred and the damage becomes almost certain year after year. In the Southern States the larvæ do much damage to corn crops and there the insect is known as the Southern corn root-worm. They also work similarly upon the roots of Johnson grass, wheat, rye, millet, oat, *Rudbeckia*, bulrush, pigweed and jimson weed. In the Northern States many other plants, like alfalfa, beans, muskmelon, watermelon, cucumber, squash, pumpkins, umbrella plant, etc., are more seriously injured. Nearly all vegetables, forage crops and weeds are also attacked, while many kinds of fruit and wild trees are not exempt.

Distribution.—This species is generally distributed throughout the United States, but is replaced in California by the Western forms, *Diabrotica soror* Leconte and *Diabrotica 12-punctata tenella* (Leconte).

Control.—Poisoned sprays as recommended for *D. soror* should also be used for this species. Where special crops, like corn, cucumbers and beans, are regularly attacked it may be advisable to plant as a rotation a crop less subject to the ravages of the beetle. Thorough cultivation is said to be helpful in reducing or preventing heavy infestations, as it destroys many of the pupæ and larvæ.

¹⁸⁵Sanderson, E. D., Ins. Pests of Farm, Garden and Orchard, p. 160, 1912.

THE OBSCURE TWELVE-SPOTTED CUCUMBER BEETLE

Diabrotica 12-punctata tenella (Leconte)(*Diabrotica tenella* Leconte)¹⁸⁶

(Fig. 263)

Description.—In size and shape this beetle greatly resembles the twelve-spotted cucumber beetle, but is easily recognized by the dark green wing covers, which are marked with very small or obscure black spots. In some species only a few faint spots show, while in others no spots at all appear. The prothorax is greenish or bright yellow, the head dark green or black, the body yellow and the legs and antennæ yellowish green or brownish. The eggs, larvæ and pupæ, though undescribed, probably vary little from those of *D. 12-punctata*.

Life History.—The life history is practically the same as for *D. 12-punctata*.

Nature of Work.—The nature of the work is the same as that of the other species of *Diabrotica*.

Food Plants.—Like the two previous species, this is a general feeder and may be found upon almost any of the crops, including alfalfa, barley, corn, cucumber, pea, squash, muskmelon, watermelon, sorghum, potatoes, weeds and fruit trees.

Distribution.—This beetle occurs only in the southeastern part of the State, having been taken most frequently in Imperial County.

Control.—Control measures as recommended for *D. soror* and *D. 12-punctata* should be employed in controlling this beetle if remedies prove necessary.

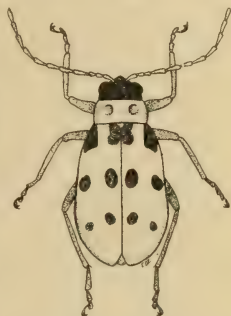


Fig. 263. — The obscure twelve-spotted cucumber beetle, *Diabrotica 12-punctata tenella* Lec. Adult, greatly enlarged. (Original)

THE WESTERN STRIPED CUCUMBER BEETLE

Diabrotica trivittata Mannerheim

(Fig. 264)

Description.—As seen by the illustration (Fig. 264), this beetle is entirely different in general appearance from the previously described species of *Diabrotica*. The adults are of the same general shape, but slightly larger, being about $\frac{2}{3}$ inch in length. The elytra are pale yellowish with three black longitudinal stripes, as shown. The prothorax is yellow, as are also the bases of the femora of the legs and the basal half of the first antennal article. The body is shiny black. This form is closely related to the Eastern striped cucumber beetle (*D. vittata* Fab.), but does not appear to be quite as destructive.¹⁸⁷

Life History.—The adults hibernate or feed largely through the winter, especially in the southern part of the State, where they remain

¹⁸⁶Townsend, C. H., Insect Life, V, p. 39, 1892.

¹⁸⁷Chittenden, F. H., Bul. No. 82, Pt. VI, Bur. Ent., U. S. Dept. Agric., p. 75, 1910.

inactive only on cold days. During the early spring months (March and April) egg-laying begins much as in the case of the other species of *Diabrotica*—the eggs being deposited under the surface of the soil about the base of the food plants. The larvæ work upon the roots underground while the adults feed upon the buds, flowers, young fruits and foliage above ground. There are evidently two broods a year.

Nature of Work.—The nature of the work of the striped species is practically the same as that of the preceding species.

Distribution.—This beetle is generally distributed throughout the entire State, being quite abundant in many localities, in the northern as well as the southern parts.

Food Plants.—The following plants are attacked by the beetle: almond, apple, apricot, bean, beet, cucumber, muskmelon, pea, prune, pumpkin, squash and watermelon. Many other plants are also attacked.

Control.—Control measures as recommended for *D. soror* and *D. 12-punctata* should be used in combating this species also.



Fig. 264.—The Western striped cucumber beetle, *Diabrotica trivittata* Mann. Adult, greatly enlarged. (Original)

THE GREEN DOCK BEETLE

Gastroides cyanica Melsheimer

(*Gastroides carya* Rogers)

(Fig. 265)

Description.—The beetles are metallic green or bluish above and black beneath. The legs and antennæ are also black. The length of the females averages about $\frac{3}{16}$ inch and the width $\frac{1}{2}$ inch. The males are slightly smaller. The eggs are bright yellow or orange, regularly oblong, $\frac{1}{16}$ inch long and laid in clusters of from three to fifty or even more. The first hatched larvæ are dull-green with body tubercles and heads black. The mature forms are black and attain $\frac{1}{4}$ inch in length. The pupæ are bright yellow at first, becoming darker with age.

Life History.—The adults hibernate and emerge in great numbers in March and April. They feed extensively before egg laying, which begins about the first of April. The eggs are laid in masses, usually upon the host or upon nearby plants, and hatch in a few days. The larvæ begin at once to feed upon the foliage and mature in two or three weeks. Pupation takes place in the soil and requires but two or three weeks. There appears to be but one large brood a year, though the shortness of it would indicate at least a second small brood.

Nature of Work.—The larvæ and adults feed upon the leaves of the host plants, eating around the edges or making irregular holes throughout or even devouring all of the foliage.

Distribution.—This beetle is a very common insect throughout the State.

Food Plants.—The native food plants are the wild dock and canaigre (*Rumex* spp.), but rhubarb is often severely attacked. Grape vines also become occasionally infested. Rhubarb is the only plant on which treatment is worth considering.

Control.—The adults are easily shaken upon sticky shields or into oily receptacles. Neutral lead arsenate sprays should be applied when the eggs begin hatching, to kill the first larvæ. Paris green and lime may also be dusted on at this time, but no poison spray should be applied to vegetable crops just ready for market, as it would not pay at that time anyway, aside from the danger of the poison to consumers.

Natural Enemies.—Two parasites have been reported as attacking this beetle in the Eastern States: *Bracon gastroides* Ashm.¹⁸⁸ and *Perilitus gastrophysæ* Ashm.¹⁸⁹

THE GRAY LEAF-BEETLE¹⁹⁰

Glyptoseclis longior Leconte

(Fig. 266)

Description.—The beetles are covered with fine white scales, giving them a grayish color. When these scales are removed the dorsum appears metallic



Fig. 266.—The gray leaf-beetle, *Glyptoseclis longior* Leconte. Adults, enlarged three times. (Original)

Distribution.—This species occurs in the central and northern parts of the State and appears to be most abundant in the Sierra foothill districts.



Fig. 265.—The green dock beetle, *Gastroides caryocarpa* Melsh. Adults and mass of eggs on a dock leaf, portions of which have been removed by the beetles. Natural size. (Original)

removed the dorsum appears metallic. The eyes are dark-brown; the legs and antennæ are light brown. The length varies from $\frac{1}{4}$ inch to $\frac{5}{16}$ inch.

Life History.—The life history of this beetle has not been worked out in California. The adults hibernate and emerge early in the spring and often do considerable damage to the young foliage of fruit trees in the mountainous districts.

Nature of Work.—The adults eat holes in the leaves and devour much of the foliage of the trees.

¹⁸⁸Insect Life, II, p. 348, 1890.

¹⁸⁹Insect Life, III, p. 57, 1891.

¹⁹⁰A small green and bronze beetle, *Colaspidea varicolor* Cr., is common throughout the State and sometimes attacks fruit trees. Pear and *Ceanothus* are known host plants. (Fig. 267)

Food Plants.—According to Dr. E. C. Van Dyke, this species normally feeds upon incense cedar and other conifers. During the spring of 1914 Mr. D. F. Norton, county horticultural commissioner, found it feeding upon the foliage of pear trees in Nevada County.

Control.—Only very rarely will control measures be found necessary. Jarring the beetles in sheets in the early morning or late evening and destroying them, and the application of poison sprays will serve to check sporadic infestations, especially upon young trees.



Fig. 267.—*Colaspidea vari-color* Cr., a small green and bronze beetle, sometimes attacking the foliage of fruit trees. Enlarged twice. (Original)

THE STRIPED DATURA BEETLE

Lema nigrovittata Guerin¹⁹¹

(Fig. 268)

Description.—The beetles are often confused with the Western striped cucumber beetle. They are larger, being $\frac{5}{16}$ inch long and considerably darker in color. The elytra are dusky yellow with three longitudinal black stripes. The prothorax is constricted at the middle with a wide transverse black band in the center, occupying nearly the entire dorsum. The head, antennæ, legs and body are black. The larvæ are yellowish or olive-green with a few dark markings and are covered with excrement.



Fig. 268.—The striped datura beetle, *Lema nigrovittata* Guer. Adult, greatly enlarged. (Original)

Life History.—The adults hibernate and emerge to begin egg-laying in the spring. The eggs are laid in masses of from four to eight on the undersides of the leaves.¹⁹² The larvæ and adults feed upon the foliage. The former secrete a thick, sticky liquid over the body, to which excrement and other waste material adhere. Pupation takes place in the ground.

Nature of Work.—The adults and larvæ feed upon the leaves and flowers, eating holes in them or devouring them entirely.

Distribution.—This is a common beetle throughout the entire State, but especially abundant in the central and southern parts.

Food Plants.—The following food plants have been recorded as hosts¹⁹²: Tolguacha or jimson weed (*Datura meteloides*) and other

¹⁹¹Prof. H. C. Fall considers this species identical with the Eastern form, *Lema trilineata* Oliv., his conclusions being based upon personal investigations and those of F. C. Bowditch.

¹⁹²Blaisdell, F. E., *Insect Life*, V, p. 35, 1892.

species of *Datura*, *Burgmansia*, *Cestrum aurantiacum* and garden and ornamental plants.

Control.—A poison spray composed of 6 to 10 pounds of neutral arsenate of lead to 100 gallons of water is effective if thoroughly and repeatedly applied. Clean culture with special regard to eliminating non-cultivated host plants is very important.

Natural Enemy.—Dr. F. E. Blaisdell¹⁹² reports the rapacious soldier-bug, *Sinea diadema* Fab. as predaceous upon the larvæ of the beetle.

THE TWO-STRIPED LEAF-BEETLE

Lupeyodes bivittatus Leconte

(Fig. 269)

Description.—The beetle is slightly smaller than the Western striped cucumber beetle, *Diabrotica trivittata* Mann., for which it is often mistaken. The head, thorax, antennæ and legs are light amber yellow; the eyes, abdomen and elytra are black, the latter having two wide longitudinal yellow stripes and a narrow yellow margin, as shown in Fig. 269. It averages $\frac{3}{16}$ inch in length.

Life History.—The life history of this beetle is unknown. The adults appear early in the spring and are often abundant in the orchards and in the flowers of the buckeye throughout the spring and early summer months.

Nature of Work.—The adults eat irregular holes in the leaves.

Distribution.—The two-striped leaf-beetle is quite common throughout the State.

Food Plants.—The California buckeye is one of the normal food plants, but the beetle also frequently attacks the foliage of almond, apricot and prune trees.

Control.—Though this insect is often quite abundant, it has never proven to be serious enough to warrant the cost of control measures.

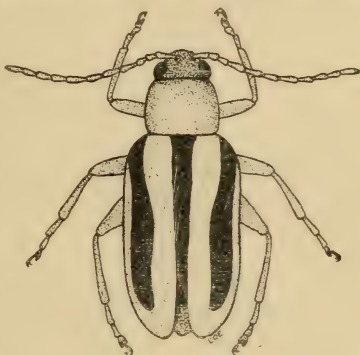


Fig. 269.—The two-striped leaf-beetle, *Lupeyodes bivittatus* Lec. Adult, greatly enlarged. (Original)

THE WESTERN BEET LEAF-BEETLE

Monoxia consputa Leconte

(Fig. 270)

Description.—The adults are pale yellowish-brown, perfectly plain or with irregular dark markings on the dorsum. They are about $\frac{1}{8}$ inch long. Descriptions or specimens of the immature stages were not available.

¹⁹²Blaisdell, F. E., *Insect Life*, V, p. 35, 1892.

Life History. — The adults are abundant late in the summer in August and September, when they often do considerable damage. These are evidently of the second brood, some of which hibernate and lay eggs in the spring. The first spring brood does not appear to cause much damage.



Fig. 270. — The Western beet leaf-beetle, *Monoria consputa* Lec. Adult, greatly enlarged. (After Chittenden, U. S. Dept. Agric.)

Nature of Work. — The larvæ and adults eat holes in the foliage of the older plants and completely destroy the young ones.

Distribution. — The insect is probably distributed throughout the entire State.¹⁹³

Food Plants. — Garden and sugar beets are the only recorded hosts,¹⁹⁴ but undoubtedly other crops are also attacked.

Control. — Control measures are the same as for the sugar-beet leaf-beetle, *Monoria puncticollis* Say.

THE SUGAR-BEET LEAF-BEETLE¹⁹⁵

Monoria puncticollis Say

(Fig. 271)

Description. — The color and markings of the adults are variable, but the dorsum is usually dull yellowish-brown with two dark longitudinal stripes on each wing cover. These stripes may be entirely wanting in some, there appearing but a narrow yellowish line around the edges

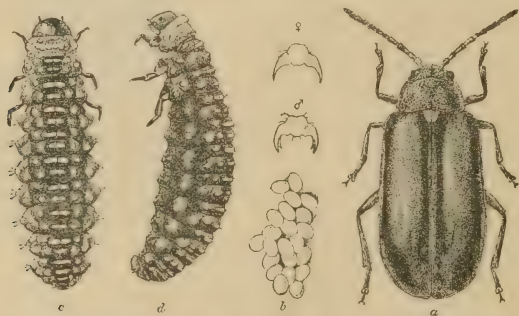


Fig. 271. — The sugar-beet leaf-beetle, *Monoria puncticollis* Say. a, adult; b, eggs; c and d, larvæ. All greatly enlarged. (After Chittenden, U. S. Dept. Agric.)

of the wing covers. The color beneath is brown. There are a number of color phases in the adult stage. The length varies from $\frac{1}{4}$ to $\frac{1}{3}$ inch. The eggs are broadly oval with surface minutely sculptured, at first light orange-colored turning to brown or dull grayish with age, about 0.032 inch long and 0.024 inch wide. The larvæ are dark olive-brown

¹⁹³Chittenden, F. H., Bul. No. 43, Bur. Ent. U. S. Dept. Agric., pp. 11-12, 1903.
Woodworth, C. W., Cal. Insects, p. 223, 1913.

¹⁹⁴Chittenden, F. H., Bul. No. 43, Bur. Ent. U. S. Dept. Agric., p. 11, 1903.

¹⁹⁵Chittenden, F. H., Bul. No. 43, Bur. Ent. U. S. Dept. Agric., pp. 9-11, 1903.

with dark brown heads and cervical shields, white anal segments and white or yellowish tubercles arranged in transverse rows on the dorsum. Each tubercle bears one or more short, stout spines. The length varies from $\frac{1}{3}$ to $\frac{1}{2}$ inch.

Life History.—The hibernating adults appear in the spring and begin to deposit their eggs in clusters upon the undersides of the leaves of the young beets or earlier upon the leaves of seed beets. The eggs hatch in about a week and the larvæ feed upon the leaves, becoming fully grown in from one and one-half to two weeks. Pupation takes place in the ground, within a few inches of the surface. Adults also work upon the foliage and often congregate in such great numbers as to do much damage. There are two broods a year.

Nature of Work.—The larvæ and adults eat holes in the foliage. If occurring in large numbers, the leaves are completely skeletonized and the plants shrivel and die.

Distribution.—According to Dr. Van Dyke, this beetle occurs in the maritime portions of the State, being generally found on the salt marshes.

Food Plants.—The foliage of sugar beets, *Dondia americana*, *D. depressa*, Russian thistle and *Atriplex argentea* are attacked. The atriplex is the normal food plant.

Control.—Liberal applications of poison sprays as recommended for the potato flea-beetle (*Epitrix cucumeris* Harris) should be used to control this beetle. A few scattering beets allowed to grow through the winter act as trap crops and may be either heavily poisoned before infestation, to kill the beetles as soon as they attack the foliage, or they may be destroyed by burning in the early morning, together with the beetles, if they do not all escape in the operation. As the attacks are rather spasmodic, control measures are seldom profitable or even necessary.

THE SMALL ELONGATED LEAF-BEETLE

Myochrous longulus Leconte

(Fig. 272)

Description.—The beetles are small, elongated, with bright metallic bronze bodies, the backs of which are covered with fine, light scales, giving them a decided gray appearance. The ventral surface, legs and antennæ are light metallic bronze, covered with short, light yellowish pubescence. The eyes are black. The head is very small and held directly beneath the front of the prothorax, the lateral margins of which are toothed. The length varies from $\frac{3}{16}$ to $\frac{1}{4}$ inch.

Life History.—The life history of this beetle is unknown, except that during the early spring (April and May) the adults often appear in great numbers and feed upon the foliage of cultivated and wild plants.



Fig. 272.—The small elongated leaf-beetle, *Myochrous longulus*, Lec. Adults, enlarged three times. (Original)

Nature of Work.—The beetles feed upon the leaves, leaving only portions of stems after them.

Distribution.—This species appears to be limited to the southern part of the State, and more particularly to the hotter southeastern portions, extending into Arizona and Mexico.

Food Plants.—The native food plants are not recorded. During April and the first of May, 1914, the State University reported a field of cotton greatly injured by its attacks.

Control.—The application of poison sprays composed of 4 pounds of neutral arsenate of lead to 50 gallons of water is recommended, though it is doubtful if control measures will ever be necessary except in extreme cases.

THE HOP FLEA-BEETLE

Psylliodes punctulata Melsheimer

(Fig. 273)

Description.—The beetles are small, metallic black or green, oval, $\frac{1}{10}$ inch long and half as wide. The eggs are very small, oval, and yellow. The grubs are white, with dusky markings, slender, and about $\frac{3}{16}$ inch long. The pupæ are white and about the size of the adults.

Life History.—The adults appear early in the spring and are ready to attack the first hop plants as soon as they come through the ground.

They feed upon the upper surfaces of the leaves, completely skeletonizing them. The vines are often entirely destroyed before they have reached a height of three or four feet. When disturbed the beetles hop or fall to the ground. They are able to make their way through the soil without much difficulty and lay their eggs upon the roots of the food plants.

The larvæ live in the ground, feeding upon the roots of various plants. When full-grown they pupate in the soil,

from which the adults emerge throughout nearly the entire year, the largest number appearing from early spring to August. There are probably two generations a year.

Nature of Work.—The larvæ work upon the roots and do little damage, while the adults work upon the leaves of hops and sometimes cause very serious losses. They eat small holes in the leaves similar to those made by other flea-beetles.

Distribution.—This beetle appears to be quite widely distributed throughout the State, but so far has not proven to be a serious pest.

Food Plants.—The following plants are attacked: beet (garden and sugar), cabbage, clover, cucumber, dock, hop, lambsquarters, mustard, nettle, potato, radish, rhubarb, sorrel, tomato and turnip. W. B. Parker, who has done much work on hop insects during the past few years in California, states that this beetle is not a hop pest in this State.



Fig. 273. — The hop flea-beetle, *Psylliodes punctulata* Mels. Adults, enlarged twice. (Original)

Control. — There have been numerous methods of control recommended for this pest. The measures directed against the hibernating beetles consist in killing all on the poles or burning up the rubbish. In the spring the first step consists in capturing the adult beetles on the young vines. A tarred board or hand hopper-dozzer is used, on or into which the beetles are shaken. Tanglefoot bands around the bases of the tressed vines, as well as around the poles, not only keep the beetles from the foliage but capture great quantities of them. This is recommended as the very best remedy for this pest by W. B. Parker,¹⁹⁶ who has had a large experience in the control of this pest. Various contact sprays, such as tobacco extract, emulsions, soaps, resin wash and arsenic, also have been used with good effect, but the cost, due to great numbers of applications necessary, makes them almost prohibitive.

THE WESTERN CABBAGE FLEA-BEETLE

Phyllotreta pusilla Horn

(Fig. 274)

Description.—The beetles are exceedingly small, shiny black with distinct bronze or greenish luster and very minute punctures on the dorsum.

Life History.—The adults hibernate and appear early in the spring. The younger plants are preferred and are often completely destroyed. The leaves of older plants also become seriously infested. The damage appears to be done entirely by the adults, as no injuries by the larvæ are recorded.

Nature of Work.—The work is like that of most of the flea-beetles and consists in destroying the young, tender plants and eating holes in the leaves of the large ones. Their attacks are often very serious.

Distribution.—This species occurs throughout the State, having been recorded from the southern part by F. H. Chittenden¹⁹⁷ and collected in the central part, around San Francisco Bay, by the writer.

Food Plants.—As the name implies, this beetle generally infests cabbage and related cruciferous crops, including mustard, radish, rape and turnip. Corn and sugar beets are also attacked.

Control.—Control measures are the same as for the potato flea-beetle, *Epitrix cucumeris* Harris.



Fig. 274 — The Western cabbage flea-beetle, *Phyllotreta pusilla* Horn. Adult. Natural size shown by line on the right. (After Chittenden. U. S. Dept. Agric.)

¹⁹⁶Bul. No. 82, pt. IV, Bur. Ent. U. S. Dept. Agric., 1910.

¹⁹⁷Chittenden, F. H., Bul. No. 43, Bur. Ent. U. S. Dept. Agric., p. 18, 1903.

THE WESTERN STRIPED FLEA-BEETLE

Phyllotreta ramosa Crotch

(Figs. 275, 276)

Description.—The beetles are black with two distinct irregular white vittæ on the wing covers. They greatly resemble the striped turnip flea-beetle (*Phyllotreta vittata* Fab.), but differ in that the vittæ are branched just back of the middle, as shown in Fig. 276. The antennæ are black, excepting the first four articles, which are amber.

The legs are dark rufous. The dorsum is quite coarsely punctured and the entire surface is covered with short light hairs. The length averages about $\frac{1}{10}$ inch.

Life History.—The life history is practically the same as that of the striped turnip flea-beetle.

Nature of Work.—The adults eat circular or irregular holes in the leaves, as shown in Fig. 275.

Distribution.—It occurs throughout the State and is often confused with the striped turnip flea-beetle, which is so common in the East and which probably does not occur in this State, as has been reported so many times.

Food Plants.—The writer has taken the adults on

mustard, radish and turnip, but it probably infests many of the *Cruciferae*.

Control.—Control measures are the same as for the potato flea-beetle, *Epitrix cucumeris* Harris.

THE STRIPED TURNIP FLEA-BEETLE

Phyllotreta vittata Fabricius¹⁰⁸

Description.—The beetles are very small, shiny black, with a wavy yellow band on each wing cover and about $\frac{1}{8}$ inch long. The eggs are white. The full-grown larvæ are dirty white, slender, covered with a few hairs and $\frac{3}{16}$ inch long.

Life History.—This is a very common species in the Eastern States. The adults hibernate and appear in April and May. They begin at once to feed upon young plants as they come up and do great

¹⁰⁸This species, though often reported from California, has always been confused in this State with the Western form, *Phyllotreta ramosa* Cr., which is the common Western species. Dr. Van Dyke and Prof. Fall both believe this to be the case.



Fig. 275.—The Western striped flea-beetle, *Phyllotreta ramosa* Cr. Adults and their work on a turnip leaf. Enlarged twice. (Original)

damage. As the plants become older and the leaves tougher the damage may be outgrown. The eggs are laid around the base of the plants and the larvæ feed upon the roots, where they do some damage. Rarely they also feed upon the leaves. There are two or three broods a year.

Nature of Work. — The adults eat very small holes in the tissues of the leaves. If very abundant, only the skeletons, consisting of the largest veins, remain. Young plants may be entirely destroyed when they first come up by their attacks. The larvæ feed somewhat upon the roots of cultivated plants, but mostly upon weeds.

Distribution. — The species has often been reported from the State, but evidently does not exist here at all, being replaced by a closely related species, *Phyllotreta ramosa* Crotch.

Food Plants. — All the members of the family *Cruciferae*, including cabbage, radish, mustard, turnip, stocks, wall flower, water-cress, etc., are attacked by this beetle.

Control. — For control measures see same under the potato flea-beetle, *Epitrix cucumeris* Horn.



Fig. 276. — The Western striped flea-beetle *Phyllotreta ramosa* Cr. Adult, greatly enlarged. (Original)

THE FRUIT-TREE LEAF SYNETA

Syneta albida Leconte¹⁰⁰

(Fig. 277)

Description. — The adult female is very light, almost white, faintly tinted with amber and the eyes are very dark brown. The male is much darker, with the head, prothorax and a stripe down the middle of the elytra almost or entirely black. The tips of the antennæ are also dark. The inner margins of the wing covers are distinctly raised, this raised portion being dark in the males. The surface is also finely punctured. The average length is $\frac{1}{4}$ inch.

¹⁰⁰A more abundant species in the State, according to Dr. E. C. Van Dyke, is *Syneta simplex* Lec., which works upon oak trees. This is about the same size as the above, but is uniformly amber-brown throughout with dark eyes. The inner margins of the wing covers are raised, but more feebly than in *S. albida*. A variety of *S. simplex* which is of the same color but considerably smaller, averaging about 3-16 inch long, is also very common in California and is usually the most injurious to fruit trees.

Life History.—The life history of this beetle does not seem to have been studied, and little is known about its habits, except that the adults often appear in considerable numbers in the spring and do some damage to the flowers and foliage of fruit trees.



Fig. 277.—Fruit-tree leaf synetas. Beginning at the left, *Syneta albida* Lec., female at top and male at bottom; *Syneta simplex* Lec., male at top and female at bottom; at right, *Syneta simplex* var., female at top and male at bottom. All enlarged three times. Specimens received from Dr. E. C. Van Dyke. (Original)

Nature of Work.—The beetles destroy the petals of the flowers and eat the leaves, especially upon the tender shoots of grafts or young trees.

Distribution.—This species is occasionally met with in the northern and central parts of the State.

Food Plants.—Various fruit trees, including apple, cherry, peach and prune, also poplar and willow, are attacked.

Control.—An application of arsenate of lead, 3 pounds to 50 gallons of water, should be made as soon as the beetles become destructive enough to warrant control measures.

THE PACIFIC BANDED FLEA-BEETLE

Systema taniata ligata Leconte²⁰⁰

(Fig. 278)

Description.—The adults are small, averaging about $\frac{1}{8}$ inch in length, and are exceedingly variable in color. They are, however,

²⁰⁰Previous California records relating to *Systema taniata* Say probably refer to two varieties: *Systema taniata ligata* Leconte and *Systema taniata ochracea* Leconte. In the last the head and thorax are reddish-brown, the side margins pale and the entire surface pale yellowish-white. This information was received from Dr. Van Dyke. (Fig. 278)

usually shiny black with two distinct longitudinal white stripes on the elytra.

Life History.—The life history of this species is not recorded, but it probably resembles that of the other flea-beetles described.

Nature of Work.—The beetles eat small holes into the leaves, reducing them to skeletons or causing them to appear sieve-like. Much injury is done if the species becomes abundant.

Distribution.—The banded flea-beetle occurs throughout the State.

Food Plants.—Bean, beet, grass and other plants are attacked by this beetle.

Control.—The control is practically the same as for the potato flea-beetle, *Epitrix cucumeris* Harris.

THE PALE-STRIPED FLEA-BEETLE

Systema blanda Melsheimer

Description.—The adults are cream-colored with the abdomen and eyes black and the wing covers marked with one broad median and two narrow marginal light brown stripes, which may be entirely wanting in some individuals. The head is reddish and the antennæ and legs are marked with light brown. The length is $\frac{1}{8}$ inch, width $\frac{1}{4}$ inch. The eggs are elliptical, two and one half times as long as wide, light buff-yellow, surface finely granulated or sculptured and about 1-40 inch long. The larvæ are slender, white, with pale brownish or amber head and legs. The anal segment tapers into a prolonged process or tubercle. The body is moderately hairy. The mature larvæ are $\frac{1}{2}$ inch long and one seventh as wide. The pupæ are light brown and about as large as the beetles.

Life History.—The adults hibernate in rubbish or other sheltered places and emerge early in the spring. The eggs are laid singly or in small masses of three or four upon the leaves, in May, June and July. They are attached by the sides. The larvæ feed underground upon the roots, while the adults feed upon the leaves. There are probably two broods a year.

Nature of Work.—As previously stated, the larvæ feed upon the roots, while the adults eat small circular or irregular holes in the leaves.

Distribution.—This species occurs in California,²⁰¹ but its exact distribution is not well known.

Food Plants.—The adults, especially, are very destructive²⁰² to plants. The following hosts are reported: wormwood (*Ambrosia artemisiaefolia*), bean (bush and lima), beet, carrot, clover, cockle bur, corn, cotton, eggplant, jimson weed, lambsquarters, muskmelon,



Fig. 278.—Banded flea-beetles. *Systema tuniata ligata* Lec. at the left and *Systema tuniata ochracea* Lec. at right. Enlarged four times. Specimens received from Dr. E. C. Van Dyke. (Original)

²⁰¹Bul. No. 23, n. s. Bur. Ent. U. S. Dept. Agric., p. 24, 1900.

²⁰²Bul. No. 23, n. s., Bur. Ent., U. S. Dept. Agric., p. 24, 1900.

nightshade, pear, purslane, tomato, turnip, strawberry and water-melon.

Control. — Control measures are the same as for the potato flea-beetle, *Epitrix cucumeris* Harris.

BRUCHIDÆ (Family)²⁶¹

PEA AND BEAN WEEVILS

Because of the prolonged head somewhat resembling a short beak or snout, these insects are called weevils though they belong to an entirely different suborder. The head is held at right angles to and beneath the body, the tarsi are four-jointed and the elytra are short so that the tip of the abdomen is exposed. The pea and bean weevils are the best known members of the family.

THE BEAN WEEVIL

Acanthoscelides obtectus (Say)
(*Bruchus obtectus* Say)

(Figs. 279, 280)

Description. — The weevils are very short and robust, measuring about $\frac{1}{2}$ inch in length. The odd shape is due to the wing covers being shorter than the abdomen and the head being carried beneath and at right angles to the body. The color varies from gray to brown with a velvety greenish tinge. The eggs are white and less than 1-25 inch long. The grubs are very small, a number of them being able to occupy a single small, white bean. They are light cream colored and robust. The pupæ are first light, gradually becoming darker with age.



Fig. 279.—Beans showing the exit holes of the bean weevil, *Acanthoscelides obtectus* (Say). Natural size. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

Life History.—The beetles, after hibernating or breeding in stored beans over winter, appear in the spring about the time the beans are blooming and lay their eggs upon the pods, in cracks at the end or in slits made by the female's

jaws. Upon hatching, the young larvae bore through the pod or reach the beans within through a natural crack and begin to enter them by drilling a small hole, the entrance of which either heals over or is so small as to be unobserved. Once within the bean, the entire life history

²⁶¹The generic name *Laridæ* and the family name *Laridæ* used in the first edition do not appear to be properly established and are therefore dropped in this revision, and the names *Bruchus* and *Bruchidæ* restored.

is spent there, the weevils emerging at will by cutting a circular hole in the side. The adults of the first brood immediately begin egg-laying upon the pods, as did the hibernating females in the field, but if in storage bins or sacks the eggs are laid upon the outside of the beans or in old burrows previously made in them. They thus continue to breed throughout the entire summer and winter if the weather is not too cold, many generations appearing each year. Under ordinary conditions, the life cycle lasts from twenty-one to eighty-one days; the egg stage from five to twenty days; the larval stage from eleven to forty-two days; the pupal stage from five to eighteen days.²⁰⁴

Nature of Work.—The small round holes in the beans, as shown in Fig. 279, indicates the presence of this pest. Practically the entire contents of the beans may be devoured. From one to fifteen, or even more, weevils may attack a single bean, depending upon the size of the host.

Distribution.—This insect is generally distributed throughout the State, and is particularly troublesome in the central and southern counties, where small beans are raised, and also in the storehouses throughout the entire State.

Foods.—Nearly all varieties of beans are attacked by this weevil, though the small white and brown varieties are preferred. Limas are only occasionally affected. Peas are also included as hosts.

Control.—The first step in the control of this pest is to harvest the beans just as soon as possible, for those left in the fields are sure to become largely infested. If any of the insects are discovered the beans should be thoroughly fumigated with carbon bisulfid before they are stored, and if weevils appear in the bins or sacks fumigation should be resorted to at once.



Fig. 280.—Adults of the bean weevil, *Acanthoscelides obtectus* (Say). Enlarged three times. (Original)

THE PEA WEEVIL

Bruchus pisorum Linnaeus²⁰⁵

[*Larix pisorum* (Linnaeus)]²⁰⁶

(Figs. 281, 282)

Description.—The weevils are about $\frac{1}{8}$ inch long, brownish-black in color, with well defined light spots on the wing covers and a distinct

²⁰⁴Bul. No. 8, n. s. Bur. Ent. U. S. Dept. Agric., p. 43, 1897.

²⁰⁵The pea weevil greatly resembles the broad-bean weevil, *Bruchus rufimanus* Boh. The principal differences are given by F. H. Chittenden in the following tabular form.

Posterior femora acutely dentate; thorax broad; pattern of elytra well defined; pygidium with a pair of distinct apical black spots-----	<i>pisorum</i> Linn.
Posterior femora obtusely or obsoletely dentate; thorax narrow; pattern of elytra more or less suffused; pygidium with black apical spots lacking or illy defined-----	<i>rufimanus</i> Boh

²⁰⁶Because of confusion and the apparent unsoundness of the generic name, *Larix* it has been dropped in the revision. See footnote 203.

white spot on the hinder part of the thorax, near the base of the wing covers. The eggs are very small and deep yellow in color. The larvae are yellowish in color, with dark heads. The pupæ are first light, gradually becoming darker with age.

Life History.—The adult hibernating weevils appear in the spring and as soon as the pods are formed on the vines and begin egg-laying. The eggs are thrust inside the pod by the females, thus being thoroughly protected and out of sight. The young larvæ, as soon as hatched, bore into the tender peas and remain inside, drilling out sufficient room until they are ready to emerge as adults in the fall or spring. This is accomplished by cutting a circular hole in one side of the pea. Unlike the bean weevil, this species works only upon the peas originally attacked when green and does not continue to breed



Fig. 281.—The pea weevil, *Bruchus pisorum* Linn. Adults and exit holes in peas. Enlarged twice. (Original)



Fig. 282.—Adults of the pea weevil, *Bruchus pisorum* Linn. Enlarged six times. (Original)

Distribution.—The pea weevil is common throughout the State, but not troublesome in all the pea-growing sections.

Foods.—It works upon all varieties of garden and flower peas.

Control.—As the seed is infested before harvesting, control measures are of little avail, except to prevent a reinfestation by means of the seed. A thorough fumigation with carbon bisulfid or hydrocyanic acid gas is a sure way of accomplishing this. No plantings should be made in fields infested the previous season, if the attacks of the beetle are to be avoided.

upon dried and stored seed. There is but one uneven brood a year.

Nature of Work.—The work of this species greatly resembles that of the bean weevil and consists in hollowing out the hosts and cutting the small, round exit holes, as shown in Fig. 281.

THE BROAD-BEAN WEEVIL

Bruchus rufimanus Boheman²⁰⁷[*Laria rufimana* (Boheman)]²⁰⁸

(Fig. 283)

Description.—The adults are from $\frac{3}{16}$ inch to $\frac{1}{2}$ inch long and a little more than half as wide. The color is black with light markings on the elytra and pygidium. The head and antennæ are dark with the basal four joints of the latter reddish-brown. The forelegs are reddish-brown and black, while the middle and hind pairs are entirely black. The eggs are light or greenish-yellow in color. The larvæ are pale-yellow or white with dark heads.

Life History.—According to Chittenden, the eggs are deposited singly and indiscriminately upon the outside of the pods, where they are plainly visible, or they are laid in the blossoms on the seed vessel before or after the pods are formed. Upon hatching, the larvæ gnaw through the pod into the growing seeds, where they continue to feed until ready to transform into the pupal stage. This stage is passed within the bean and the adult emerges by cutting a circular hole in the skin. This species hibernates in the adult stage, there being but one generation a year. Egg-laying begins in March and April, hence the adults live for a period of from eight to nine months.

Nature of Work.—The appearance of the work of this species is the same as that of the bean and pea weevils.

Distribution.—This species seems to be quite generally distributed throughout the central and southern part of the State. It has been taken by W. B. Parker at Sacramento, Berkeley, Richey, Amador County, and by I. J. Condit at San Luis Obispo. It has also been



Fig. 283.—The broad-bean weevil, *Bruchus rufimanus* Boh. Adult on broad-bean and the exit hole. Enlarged four times. (Original)

²⁰⁷Bul. No. 96, pt. V, Bur. Ent. U. S. Dept. Agric., 1912.

²⁰⁸Because of confusion and the apparent unsoundness of the generic name, *Laria*, it has been dropped in the revision. See footnote 203.

taken at Watsonville.²⁰⁷ The writer has obtained specimens from warehouses in San Francisco.

Food.—The broad-bean weevil gets its name from its work upon the broad beans (*Vicia faba*), which are also known as horse, Windsor, tick and English dwarf beans.

Control.—While many remedies have been recommended for the control of bean and pea weevils, there is nothing that will compare with fumigation in an air-tight receptacle. Carbon bisulfid, at the rate of 3 pounds to each 1,000 cubic feet of air space for a period of forty-eight hours, is recommended for small lots and hydrocyanic acid gas, at the rate of 2 ounces of cyanide to 100 cubic feet of air space, one hour for large quantities.

TENEBRIONIDÆ (Family)

DARKLING GROUND BEETLES

In California the darkling ground beetles are numerous and, though especially abundant in the hot and dry desert regions, they are none the less common in the cooler belt along the coast. In contrast to the swift moving predaceous ground beetles (*Carabidæ*), the members of this family are comparatively slow and sluggish, though some of the smaller species are also very active. The body walls are usually very thick and horn-like and the color dull, black, brown or gray. The joints of the antennæ are bead-like. The tarsi of the front and middle legs are five-jointed, while those of the hind legs are four-jointed. The head is without a distinct neck and narrower than the thorax. The larvæ of some species are cylindrical, smooth and hard, resembling in a marked degree the larvæ of the click-beetles (*Elateridæ*) and are therefore commonly called "false wireworms." The adults ordinarily live upon partially decomposed or dry vegetable matter, but not infrequently they attack living vegetation and do considerable damage to crops.



Fig. 284. — A false wireworm, the larva of a tenebrionid beetle. Natural size. (Original)

THE DESTRUCTIVE ELEODES²⁰⁸

Eleodes omissa borealis Blaisdell

(Fig. 285)

Description.—The beetle is dull black throughout and about $\frac{1}{2}$ inch long. The general appearance is shown in Fig. 285.

Life History.—Practically nothing is known concerning the life history of this species. The adults appear in the early summer, often in great numbers, and in a short time disappear almost as quickly as they came.

Nature of Work.—The destructiveness of this beetle, like that of its relatives, is great only in newly cleared districts, where, being

²⁰⁷Bul. No. 96, pt. V, Bur. Ent. U. S. Dept. Agric., 1912.

²⁰⁸Mo. Bul. Cal. Hort. Com., II, p. 627, 1913.

robbed of its normal food plants, it turns to the cultivated crops as a means of subsistence. With the continuance of cultivation their numbers rapidly diminish and also their destructiveness.

Distribution.—This species is limited more particularly to the arid desert regions of the southern and central parts of the State. It was specially abundant in Kern County during May and June, 1913, when quite a serious outbreak occurred.

Food Plants.—The leaves of apricot, orange and plum are attacked and the trees may be almost denuded of their foliage. Watermelon vines are also injured.

Control.—Poison sprays and baits do not appear to give satisfactory results in the control of this beetle. Fortunately, it is only occasionally a pest, and then for but a short time. For these reasons, it is not good economy to attempt control, except in extraordinary cases. The beetles may then be kept from climbing up the tree trunks by tin or cotton barriers, but there seems to be no way of adequately protecting vines growing close to the ground except by wire screen coverings.



Fig. 285.—The destructive *Eleodes, Eleodes omissa borealis* Blaisd. Adult female, enlarged twice. (Original)

THE SMALL DARKLING GROUND BEETLE

Eurymetopon bicolor Horn²⁰⁹

(Fig. 286)

Description.—The beetles are rather small and dull black in color. The elytra are faintly carinated and the antennæ distinctly beaded. The length is about $\frac{1}{4}$ inch and the width less than $\frac{1}{8}$ inch. Fig. 286 shows the general appearance.



Fig. 286.—The small darkling ground beetle, *Eurymetopon bicolor* Horn. Adults, enlarged twice. (Original)

Life History.—Very little is known relative to the life history of many of the darkling ground beetles, excepting that the larva greatly resemble the wireworms and live in the soil. The adults also live on the ground, under clods, leaves, or in the soil. Occasionally, however, they attack growing plants and trees and do great damage to foliage, especially in the spring of the year.

Nature of Work.—The beetles eat the foliage of plants and trees and holes in the fruit of such low plants as tomatoes, berries, etc.

Distribution.—The species appears to be injurious only in the southern part of the State.

²⁰⁹The identity of this species is questioned by Prof. H. C. Fall. A closely allied species, *Eurymetopon cylindricum* Casey, has been reported attacking the foliage of prune trees at Nordhoff, Ventura County. (Insect Life, V, p. 350, 1893)

Food Plants.—During the year 1913 the beetles were found to be destructive to the foliage of apricot and apple trees by Mr. S. A. Pease in San Bernardino County and to tomato vines and fruit by Mr. A. S. Hoyt in Los Angeles County.

Control.—Control measures are very difficult. Many of the adults may be kept from the foliage of fruit trees by tanglefoot bands, as they usually climb up the trunk, but in a garden only a rotation of crops is advised. Poison sprays are of little avail unless applied very strongly, and in such cases are likely to injure the foliage. On the whole the damage rarely warrants the cost of such measures.

MELOIDÆ (Family)

ELISTER BEETLES

The bodies of the blister beetles are comparatively soft and the wing covers are also soft and flexible; the head is as wide as the prothorax and attached by a visible neck; the tarsi of the front and middle legs are five-jointed and those of the hind legs are four-jointed. The colors are usually dark with a shining iridescence. The adults are often found feeding on foliage and flowers and thus are frequently orchard and garden pests. The common name is derived from the pulverized powder obtained by drying the bodies of the beetles and used for making blister-plasters. The transformation of a few of these beetles is remarkable in that more than three stages of metamorphosis are involved. The larvæ pass through four distinct stages before the pupal, and then the adult stages are reached. This phenomenon is called hypermetamorphosis.

THE SPOTTED BLISTER BEETLE

Epicauta maculata Say

(Fig. 287)

Description.—The ground color of the beetles is black, but the dorsum is clothed with numerous fine tufts of light hairs, giving a gray spotted appearance. The average length is about $\frac{1}{2}$ inch.



Life History.—Nothing is recorded relative to the life history of this beetle, other than that it often becomes very abundant and quite destructive during the late spring and early summer of some years.

Nature of Work.—The adults attack the leaves, eating holes into the tissues or around the edges.

Distribution.—The beetle occurs in the arid districts in the southeastern part of the State and in Modoc County.

Food Plants.—Clover, potato and sugar beet are known host plants, but attacks are probably extended to many other plants.

Control.—The application of neutral arsenate of lead, 2 pounds to 50 gallons of water, should be used if the beetles become serious pests.

Fig. 287.—The spotted blister beetle, *Epicauta maculata* Say. Adult enlarged twice. (After Chittenden, U. S. Dept. Agric.)

THE LARGE BLACK BLISTER BEETLE

Lytta insperata (Horn)
(Cantharis insperata Horn)

(Fig. 288)

Description.—The beetles are shiny black with often a rich blue metallic luster. There is a very small but distinct red spot near the middle of the face, just above the eyes. The ventral surface of the body is clothed with very fine, short, light hairs. The females average about $\frac{3}{4}$ inch long and the males about $\frac{5}{8}$ inch long.

Life History.—The life habits of this beetle have not been studied. The adults appear in great numbers in May and become so thick as to be quite injurious.

Nature of Work.—The beetles strip the plants of their foliage, entirely ruining the small hosts and greatly retarding the growth of large ones.

Distribution.—The beetle occurs throughout the southern part of the State.

Food Plant.—During the latter part of May and the first of April, 1914, R. S. Vaile recorded this beetle as doing much damage to the sugar beets at Oxnard, Ventura County.

Control.—The attacks of this beetle are infrequent and then for only a short period. If serious, poison sprays (neutral arsenate of lead, 4 pounds to 50 gallons of water) might be tried in the infested areas. A hopper-dozer run over the beets might also catch large numbers, but if employed a rather heavy distillate oil should be used in the pan.



Fig. 288.—The large black blister beetle, *Lytta insperata* (Horn). Males and females, enlarged one and one half times. Specimens received from R. S. Vaile, Oxnard. (Original)

THE INFERNAL BLISTER BEETLE

Lytta stygica (Leconte)
(Cantharis stygica Leconte)

(Fig. 289)

Description.—The beetle varies in color from black to metallic prussian-blue or brilliant metallic green throughout and is from $\frac{3}{4}$ to nearly $\frac{1}{2}$ inch in length. Fig. 289 shows the general characteristics very well.

Life History.—The life history of this species is not well known. The adults often appear in great numbers during the summer and do considerable damage to growing plants.

Nature of Work.—The beetles eat ragged holes in the leaves or completely defoliate the plants. Buds and blossoms are also devoured.



Fig. 289.—The infernal blister beetle, *Lytta stygica* (Lec.). Adult females, natural size. (Original)

Distribution.—This beetle is quite common throughout the State, especially in the higher altitudes.

Food Plants.—The flowers and buds of asters²¹⁰ and the foliage of lilac²¹¹ and other bushes are attacked. The petals of the California poppy are a favorite food in some districts.

Control.—The attacks of this beetle, though at times quite severe, are usually only of short duration and control measures under such conditions are hardly warranted.

RHYNCOPHORA (Suborder)

WEEVILS

The name *Rhyncophora* is given to beetles which are commonly known as weevils, billbugs, snout beetles and curculios, because the front of the head is prolonged into a snout at the tip of which are situated the mouth-parts. The snout or beak may be long, slender and curved or straight, stout and short. The labrum and palpi of the mouth-parts are wanting and the antennae are elbowed, enlarged at the tip and arise from the sides of the snout. The body is short, stout, usually very hard and sometimes covered with fine scales. The larvæ are soft, white, wrinkled, legless grubs which live within or on the tissues or stems of plants, in fruits, nuts and vegetables and in bark or hard wood of trees. There are six important families characterized as follows:

1. *Otiorynchida*.—There is a scar at the tip of the mandibles; the dorsum of the last abdominal segment of the male is divided transversely so that this sex appears to have one more body segment than the female. They are commonly known as scarred snout-beetles. These beetles often become troublesome, especially in California, where in the absence of the normal food plants, they invade the orchards and gardens which have replaced the native vegetation.

2. *Curculionida*.—There is no scar at the tip of the mandibles, but the males have the divided posterior segment as in the *Otiorynchida*. There is a strong fold near the outer margin of the wing covers. The adults are known as curculios. To this family belong the fruit and nut curculios which are so troublesome in other parts of the United States.

3. *Calandrida*.—The last abdominal segment of both sexes is undivided and vertical; the tibiae are not serrate. The lateral edges of the metathorax and abdomen fit into a groove in the wing-covers. The

²¹⁰Childs, Leroy, Mo. Bul. Cal. Hort. Com. III, p. 731, 1913.

²¹¹Mo. Bul. Cal. Hort. Com. III, p. 668, 1913.

beetles are commonly called billbugs or granary weevils and do much damage to growing and stored crops and cereals.

4 and 5. *Ipidæ* and *Scolytidæ*.—The last abdominal segment of both sexes is also undivided, but the pygidium is horizontal and the tibiae usually serrate. The members are mostly borers and wood engravers and do much damage to growing trees and to manufactured wood products.

6. *Rhynchitidæ*.—The members of this family have the elytra or wing-covers feebly folded and the mandibles toothed on the outer and inner sides. This is a small family of which the most common member is the rose snout-beetle which is quite injurious to roses throughout the country.

THE ADALERES

Adaleres ovipennis Casey²¹² (Family Otiiorhynchidæ)

(Fig. 290)

Description.—The weevils are a uniform gray color of a pepper and salt combination. The size varies considerably, but the average is about



Fig. 290.—The Adaleres, *Adaleres ovipennis* Casey. Adults, egg-mass and peach leaf showing injury. Enlarged twice. Specimens received from C. L. Flint, San Luis Obispo. (Original)

7-18 inch in length and $\frac{1}{4}$ inch in width. The eyes are black and very small. The snout is wide and short, and with the head is no longer

²¹²A closely allied species occurring in the southern part of the State is *Adaleres humeralis* Casey. It is also likely to become destructive to fruit trees.

than the prothorax. There are no wings present. The eggs are cylindrical or lozenge shaped, being somewhat curved in the middle and $\frac{1}{16}$ inch long. They are shiny white and laid side by side in masses of irregular rows, all being glued together.

Life History.—Nothing is known of the life history except that during May the adults sometimes appear in the orchards and eat the foliage of fruit trees.

Nature of Work.—The adults eat the edges of the leaves, making them appear very ragged.

Distribution.—The weevils have been collected in orchards of San Luis Obispo County by C. L. Flint, in May, 1914, but are normally found in the northern and central coast counties.

Food Plants.—The almond is the only orchard tree so far recorded as a host. The adults feed normally upon such native plants as live oak and *Ceanothus* sp.

Control.—The adults may be jarred from the trees and, as they are wingless, their reascending may be prevented by bands of cotton or tanglefoot around the trunks.

THE WHITE BUD-WEEVIL

Eupagoderes morticallis Fall (Family Otiorhynchidae)

(Fig. 291)

Description.—Most of the weevils of this species are faint bluish-white with fairly constant black markings as shown in Fig. 291.



Fig. 291.—The white bud-weevil, *Eupagoderes morticallis* Fall. Adults, enlarged twice. Specimens received from A. R. Baird, Inyo. (Original)

Some specimens, however, are decidedly brown instead of white. The abdomen is very large and nearly hemispherical in shape, while the head and prothorax are quite narrow. The snout is wide and short. The antennae are scarcely longer than the snout and head together. The length varies from $\frac{1}{4}$ to $\frac{3}{8}$ inch.

Life History.—This weevil is rather a rare species and little is known concerning its habits, except that it normally feeds upon sage brush, but has, during the past two years appeared in great numbers in April and May and destroyed fruit buds just as they were beginning to open.

Nature of Work.—The adults eat the entire fruit buds just as they are beginning to open in the spring of the year.

Distribution.—Inyo County is the only place in the State where the weevil has proven a pest. Its occurrence elsewhere has never been reported.

Food Plants.—Wild California sage is the native food plant, but for two years apple trees²¹³ have been seriously damaged by the destruction of the buds.

Control.—Thorough spraying with arsenate of lead when the buds begin to swell may prove sufficient to hold the pest in check. An application of Bordeaux mixture at this time may suffice as a repellent. So far control measures have not been justifiable, in that the cost of spraying would be many times greater than the actual loss due to the work of the weevil.

FULLER'S ROSE BEETLE

Pantomorus fulleri (Horn) (Family Otiorynchidae)

(*Aramigus fulleri* Horn)

(Fig. 292)

Description.—The weevils vary from gray to very dark brown, with an oblique white stripe on the sides of the wing covers near the posterior end. They are wingless. The length varies from $\frac{3}{8}$ to $\frac{1}{2}$ inch. The eggs are ovoid or elliptical, pale yellow, smooth, about 1-25 inch long and are laid in irregular rows in masses of from ten to sixty. The larvæ are white, $\frac{3}{8}$ inch long and legless. The pupæ are white and slightly shorter than the grubs.

Life History.—The eggs are usually deposited in masses between the loose bark and the trunks of the trees, near the base, just above the ground, upon the stems of smaller plants or upon the ground near the base of the host. They hatch in about a month. The young larvæ are subterranean in habits and feed upon the roots of many plants. When full-grown they pupate in the soil from two to five inches below the surface and emerge as adults. These are very slow, sluggish weevils which are unable to fly and must crawl from the ground up the trunk or other portion of the host touching the ground. They feed upon the foliage. The winter is spent in the adult stage, the weevils being in evidence and often feeding practically throughout the entire winter in the southern part of the State.

Nature of Work.—The larvæ entirely destroy the roots of many plants, causing death. As the work is underground, the cause of the trouble often remains a mystery to the untrained observer. The work of the adults, however, is very obvious, as both the work and the weevils are usually to be found together. Irregular holes are eaten in the middle or around the edges of the leaves, and young tender shoots are often entirely devoured, especially those of newly budded or grafted citrus trees. Fig 292 shows the characteristic work on the older foliage.

Distribution.—Fuller's rose beetle is destructive in the southern and central parts of the State. It has been reported as far north as Alameda County.

²¹³Mo. Bul. Cal. Hort. Com., II, p. 597, 1913.

Food Plants.—The larvæ work upon the roots of various plants, including blackberries, loganberries, raspberries, roses, strawberries and probably many unrecorded hosts. The adults have been found feeding upon *Abutilon*, *Acacia*, *Achyranthes*, apricot, azalea, *Begonia*, California fan palm (*Washingtonia filifera*) and other palms, camellia,



Fig. 292.—Fuller's rose beetle, *Pantomorus fulleri* (Horn). Adults and their work on lemon leaves. Beetle on left, enlarged twice; those on the right, natural size. Specimens from S. H. Essig, Ventura. (Original)

Canna indica, cape jasmine, carnation, *Cissus*, citron, dracena, geranium, grapefruit, *Hibiscus*, leadwort, Java plum, lemon, lilies, oak, orange, pear, persimmon, primrose, rose, tangerine and *Vinca*.

Control.—The larvæ, like all subterranean pests, are very difficult to control, but thorough cultivation and hoeing close to the plants will destroy many. In light soil, carbon bisulfid is efficient, but is likely to kill the plants if great care is not exercised in the application and is too expensive to be available for ordinary crops. As the adults are unable to fly, it is only necessary to employ some means to keep them from crawling up the trunks or branches of the trees or plants. On low trailing plants this is very difficult, but on trees the use of tangle-foot or cotton bands about two feet from the ground has proven very

practicable and are especially useful for protecting newly budded or grafted trees. In some cases it is necessary to prune to prevent limbs touching the ground and affording a means of ascent. Poison sprays composed of 3 or 4 pounds of neutral lead arsenate to 50 gallons of water are recommended where the bands can not be used.

THE APRICOT LEAF-WEEVIL

Paraptochus sellatus Boheman (Family Otiiorhynchidae)

(Fig. 293)

Description.—The adults are uniformly dark brown in color with two rather faint oblique white lines on the sides of the elytra near the posterior end. In many respects they resemble miniature forms of Fuller's rose beetle, being about one third as large, but much darker in color. Individuals vary in size, but the average is about $\frac{3}{16}$ inch in length. The snout is wide and short, about as long as the head. The prothorax is coarsely punctured. The elytra are distinctly carinated and covered with rather long, coarse hair. The head is slightly narrower than the prothorax, which is about half as wide as the remainder of the body.

Life History.—The life history of this weevil is very imperfectly known. The eggs and larvæ have never been observed, but during the last of May and the first of June the adults gather in large numbers upon the hosts and do much damage. They disappear during the last of June. Adults

are often observed in rather large masses clinging to one another very tightly. When disturbed they draw the legs and antennæ close to the body and will remain motionless for some time.

Nature of Work.—The adults eat around the edges as well as holes through the leaves, sometimes devouring practically all of the foliage upon some shoots, especially those on the inside of the trees. Young fruit is also eaten.

Food Plants.—So far as known the apricot is the only economic plant attacked, but for two years quite serious damage has been done in limited areas. It normally feeds on the coast live oak.



Fig. 293.—The apricot leaf-weevil, *Paraptochus sellatus* Boh. Adults and their work on an apricot leaf, natural size. Specimens from S. H. Essig, Ventura. (Original)

Distribution.—This weevil was first observed as a destructive pest by S. H. Essig in Ventura County, where it was abundant during May and June in 1913 and 1914. Fall²¹⁴ records it in Los Angeles County near Pomona. No other records are available relative to its distribution in California.

Control.—As the adults can not fly, control measures consist in jarring them to the ground and putting tanglefoot bands around the trunks of the trees to prevent their climbing back. Poison sprays are of little avail in controlling such a pest.

THE SMALL GRAY LEAF-WEEVIL

Thricolepis inornata Horn (Family Otiorynchidae)

(Fig. 294)

Description.—The weevils greatly resemble miniature Fuller's rose beetles in color and shape. They are light gray with a white spot at the middle base of the elytra, a white line on each side of the prothorax



Fig. 294.—The small gray leaf-weevil, *Thricolepis inornata* Horn. Eggs and adults, slightly enlarged. (Original)

and an oblique white line on each side of the elytra near the posterior end. The elytra entirely cover the body, except a small area of the ventral surface. The prothorax is narrow, scarcely wider than the head, and nearly as long as the head and snout together. The antennae are short and elbowed. If the light gray and white scales are rubbed from the body it appears black. The entire body is covered with short stiff hair. The length varies from $\frac{1}{16}$ to $\frac{3}{16}$ inch. The eggs are pearly white, elongate or nearly cylindrical, slightly curved and about $\frac{1}{32}$ inch long. They are laid on the side in clusters of thirty or more.

Life History.—Very little is known concerning the life history of this weevil. The adults hibernate and often become quite destructive to foliage in the spring (April and May), when the eggs are laid. The larval stage has not been observed. Eggs were laid in clusters upon the leaves in confinement and hatched within two weeks.

Nature of Work.—The adults eat around the edges of the leaves or holes into the leaves.

Distribution.—The weevil has been received or taken in the southern, central and northern parts of the State, so its distribution is quite general.

²¹⁴Proc. Cal. Acad. Sci. VIII, p. 188, 1901.

Food Plants.—The foliage of almond, coast live oak, white oak, peach, plum and prune are eaten. The coast live oak appears to be the normal host.

Control.—As the adults are unable to fly, they may be shaken from the trees and their reascending prevented by tanglefoot or cotton bands around the trunks of the trees. However, as their attacks are rare, control measures are seldom, if ever, necessary.

THE BRONZE APPLE-TREE WEEVIL

Magdalis anseensis Leconte (Family Curculionidae)

(Fig. 295)

Description.—The weevils are dark metallic bronze with quite a long snout, as shown in Fig. 295. The length of the body is from $\frac{1}{2}$ inch to $\frac{3}{4}$ inch. The grubs are very small, legless and white.

Life History.—According to Wilson and Lovett,²¹⁵ the eggs are laid in punctures about $\frac{1}{6}$ inch deep, which have been made in the dead or living bark by the snout of the female. It requires a couple of weeks for the eggs to hatch. The young grubs immediately begin to make galleries in the bark and remain in these until pupation takes place in the spring of the year, when they emerge as adults.

Nature of Work.—The small circular or oval egg-punctures are easily observed in the bark. The grubs make small burrows from the egg cells and their work appears to be limited entirely to the bark.

Distribution.—This weevil is widely distributed in the Pacific Northwest and probably occurs only in the extreme northern part of California.

Food.—The apple trees are the only reported hosts of this weevil.

Control.—The observations of Wilson and Lovett lead to their recommending the cutting out of the bark around and including the egg-punctures, as the most satisfactory control measure.

Natural Enemy.—The parasite, *Chirapachys colon* Linn., has been reared from this weevil.



Fig. 295.—The bronze apple-tree weevil, *Magdalis anseensis* Lec. Adults, enlarged three times. (Original)

THE BLACK FRUIT-TREE WEEVIL

Magdalis gracilis Leconte (Family Curculionidae)

(Fig. 296)

Description.—The adults are small, dull-black weevils, from $\frac{1}{4}$ to $\frac{3}{8}$ inch long. The head is much narrower than the prothorax; the snout

²¹⁵Bien. Crop Pest and Hort. Rept. Ore. Agric. Exp. Sta., p. 159, 1911-1912.

is about as long as the prothorax and longer than the head. The antennæ are short and the elytra are strongly carinated. The entire body is covered with fine light hair, producing a grayish color. The immature forms are small, white, legless grubs, feeding in the twigs or limbs of trees.



Fig. 296.—The black fruit-tree weevil, *Magdalis gracilis* Lec. Adults and their work on almond leaves. Natural size. Specimens collected in the Santa Clara Valley by Leroy Childs. (Original)

Life History.—The life history is practically the same as for the bronze apple-tree weevil (*Magdalis aeneus* Lec.), the larvæ also work in the twigs of fruit trees, having been bred from an apple tree in Alameda County.

Nature of Work.—The work of the grubs is much the same as other small borers. The work of the adults is shown very well in Fig. 296, and consists in removing the epidermis of the leaf only, or in cutting holes entirely through the tissues.

Distribution.—The distribution of this weevil appears to be throughout the central and northern parts of the State.²¹⁶ It has been collected in the Santa Clara Valley by Leroy Childs (April 18, 1914), and Dr. E. C. Van Dyke reports it as generally distributed in the San Francisco Bay region.

Food Plants.—Dr. E. C. Van Dyke has reared the adults from apple trees which were infested by the grubs. The adults proved quite serious to the foliage of almond trees in the Santa Clara Valley in April, 1914. Prof. R. W. Doane reports considerable injury to the foliage of apricot, apple and peach in Santa Clara and Solano counties.

²¹⁶Full, H. C., Proc. Cal. Acad. Sci., VIII, p. 195, 1901.

Control.—The attacks of the weevil in question have so far been few and of short duration and there has been little need of control. If they do become serious, arsenical sprays should be applied to the foliage as soon as the adults appear in April. Quantities of weevils may be easily jarred into sheets and destroyed.

THE POTATO STALK BORER²¹⁷

Trichobaris trinotata Say (Family Curculionidæ)

(Figs. 297-300)

Description.—The beetles average $\frac{1}{4}$ inch in length and $\frac{1}{16}$ inch in width. The ground color of the entire body is dull-black, but the body is covered with light-gray scales, which are sparsely arranged on the dorsum, giving a slate-gray appearance, and so thick on the ventral surface as to make it appear light-gray or silvery. At the union of the prothorax and wing covers, and on portions of each, there are three black spots, where the scales are wanting, one in the middle and one at the margin on each side. Other parts which are black, because of the lack of scales, are the head, end of snout, antennæ, a small area on the ventral surface of the abdomen near the anal end, the ventral sides of the prothorax and the hind coxæ. The eyes are also black. The collar or front margin of the prothorax is orange-yellow. The head is very small with curved snout which is as long as the prothorax. The eggs are very small, oval and pearly white. The larvæ are white or yellowish with light brown heads. They are legless and bent, as shown in Fig. 298. The back and sides are rough because of the



Fig. 297. The potato stalk borer, *Trichobaris trinotata* Say. Larvæ and their work in green potato stalks. Natural size. (Original)

²¹⁷There is some question regarding the identification of this species. Dr. Van Dyke has made very careful comparisons with other species and finds it more like the above species than any other. In fact, the only noticeable difference is in size, the California form being a little larger than that of the Middle States. Chittenden has recorded *Trichobaris mucorea* as a tobacco pest in this State (Bul. No. 38, n. s. Bur. Ent. U. S. Dept. Agric., pp. 66-70, 1902).

Matthew Cooke refers to the potato stalk borer as attacking the Jimson weed in the southern part of the State (Inj. Ins. Orchard, Vineyard, etc., pp. 206-307, 1883).

From both of these references it will be seen that there is some confusion regarding the two species. Probably the insect attacking tobacco is the potato stalk borer and without doubt the beetle referred to by Matthew Cooke is *Trichobaris mucorea* Lec.

numerous short tubercles or body projections. The full-grown specimens vary from $\frac{3}{8}$ to $\frac{1}{2}$ inch in length. The pupæ are at first the color of the larvæ, but gradually assume that of the adults. They are $\frac{5}{16}$ inch long and enclosed in oval, greenish cocoons which are about $\frac{1}{2}$ inch long and constructed from the frass and chewed bits of the stalks. They are usually located within the burrows.



Fig. 298.—The potato stalk borer, *Trichobaris trinotata* Say. Larvæ, enlarged three times. (Original)

out, continuing their burrows beneath the surface of the ground. By the middle of May the larvæ are full-grown and at once begin to construct the pupal cells from bits of the chewed potato stalks. These cells are made within the burrows. Pupa-tion requires about one month and the adult stage is reached by the middle of June. The weevils do not generally leave the burrows at this time, however, but hibernate there until the following spring. Those which do emerge remain under rubbish or in sheltered places. There is but one brood a year.

Nature of Work.—

The larvæ make their burrows in the branches and main stalks of the plants, causing them to wilt and die, thus preventing the proper maturing of the tubers. In cutting open the infested stalks, the burrows, filled with frass, and the larvæ or pupæ may be seen. Fig. 297 shows the nature of the work in freshly killed stalks.



Fig. 299.—The potato stalk borer, *Trichobaris trinotata* Say. Pupæ in dead stalks and cocoons removed to show shape and texture. Slightly enlarged. (Original)

²¹⁸These data are for Imperial County only.

Distribution.—Unless the tobacco stalk weevil referred to²¹⁷ proves to be the same species, the first recorded locality is Brawley, Imperial County, where it was discovered in the spring of 1914 by Mr. Ross, in his potato patch. It has not been reported in any other locality in Imperial County.

Food Plants.—In this State the potato is the only recorded host. It will, however, also work upon other solanums like the eggplant. Two closely allied species, *Trichobaris mucorea* Lec., and *T. compacta* Casey attack the common jimson weed (*Datura meteloides*), and the former



Fig. 300.—The potato stalk borer, *Trichobaris trinitata* Say. Adults, enlarged three times. (Original)

has also been recorded as attacking tobacco.²¹⁹ In the Middle States the horse-nettle²²⁰ is a common host of the potato stalk borer.

Control.—As the adults hibernate in the old stalks, the pest is comparatively easily controlled by carefully burning all of the stalks and rubbish in the field as soon as the potatoes are dug in the fall. Any native host plants should also be destroyed at the same time or during the winter.

THE GRANARY WEEVIL

Calandra granaria Linnaeus (Family Calandridæ)

(Fig. 301)

Description.—The weevils are of a uniform shining chestnut-brown color, rather slender and from $\frac{1}{8}$ to $\frac{1}{6}$ inch long. The prothorax is coarsely punctured with rather long holes. No wings are present. The larvæ are white, legless, rather robust and distinctly segmented. They are somewhat shorter than the adults. The pupæ are the same size as the adults and vary from white, at beginning of pupal stage, to the color of the adults just before they emerge. The eggs are

²¹⁷There is some question regarding the identification of this species. Dr. Van Dyke has made very careful comparisons with other species and finds it more like the above species than any other. In fact, the only noticeable difference is in size, the California form being a little larger than that of the Middle States. Chittenden has recorded *Trichobaris mucorea* as a tobacco pest in this State (Bul. No. 38, n. s. Bur. Ent. U. S. Dept. Agric., pp. 66-70, 1902).

Matthew Cooke refers to the potato stalk borer as attacking the Jimson weed in the southern part of the State (Inj. Ins. Orchard, Vineyard, etc., pp. 206-307, 1883).

From both of these references it will be seen that there is some confusion regarding the two species. Probably the insect attacking tobacco is the potato stalk borer, and without doubt the beetle referred to by Matthew Cooke is *Trichobaris mucorea* Lec.

²¹⁹Bul. No. 38 n. s. Bur. Ent. U. S. Dept. Agric.

²²⁰Insect Life, V, p. 135, 1892.

white, nearly elliptical or slightly enlarged at one end and exceedingly minute.

Life History.—The females puncture the grain with the snout and insert eggs into the holes. The larvæ eat out the interior of the kernels and when full-grown pupate within a kernel or construct a pupal case by gluing a number of small kernels or fragments, inside of which the pupal stage is formed. In small grains like wheat and



Fig. 301.—The granary weevil, *Calandra granaria* Linn. Adults on grains of wheat. Enlarged four times. (Original)

barley a single larva inhabits a kernel, while in larger grains, like corn, several may be found in a single kernel. The adults also feed upon the grain. They are exceedingly prolific and produce large broods. The length of the life cycle depends upon the temperature and varies from four weeks in summer to many weeks in winter or in cool summer climates. As many as six broods may be produced in the southern part of the State.

Nature of Work.—The larvæ hollow out the kernels, leaving round exit holes, or eat around the outside, as do also the adults.

Distribution.—This weevil is very generally distributed throughout the State.

Food.—Nearly all forms of stored grains, including barley, chick pea, corn, kaffir corn, oat and wheat, are attacked.

Control.—The successful control of this weevil depends upon carefully carrying out certain details, among which are the following:

1. Prompt cutting and threshing of the grain as soon as ripe to prevent infestation in the fields and subsequent introduction of the weevil to the granary.
2. The use of only dry, well ventilated, tight bins and granary.
3. Clean methods in handling the grain both in field and granary.
4. The treatment by fumigation of infested material before storage.
5. Frequent inspection of the granary and prompt treatment as soon as pest appears.

TREATMENT

There are three important methods used in the treatment of stored grain and manufactured grain products for mill insects. They are, (1) fumigation with carbon bisulfid, which is specially good for grain or products stored in tight, shallow bins; (2) fumigation with hydrocyanic acid gas in cases where the bins are large and deep, and (3) the heating method which is specially recommended for large mills. Of the three carbon bisulfid is most dangerous, because of its inflammable and explosive character, and it is quite expensive. Hydrocyanic acid gas is dangerous to humans and quite expensive. Either of these processes, however, if carefully executed is quite practical for treatment on a small scale. The heating process is very expensive to install, but after the installation it is the cheapest, safest and most successful way to handle any insects infesting stored cereals or products made from them.

(1) *Carbon Bisulfid.*—Before fumigating, care should be taken to make the container as tight as possible. The temperature should be seventy degrees Fahrenheit or above, as poor and unsatisfactory results are sure to follow even excessive doses at a lower temperature. In a tight compartment 5 pounds of carbon bisulfid to every 1,000 cubic feet of air space gives excellent results in killing the weevils. If the compartment can not be made tight the amount of carbon bisulfid should be increased.

(2) *Hydrocyanic Acid Gas.*—This is specially recommended for large, deep bins or roomy storehouses and should be used at the rate of from 1 to 4 ounces of potassium or sodium cyanide to 100 cubic feet of air space, the amount depending upon the relative tightness of the room.

(3) *Heating.*—A steam heating system is necessary to carry out this process and must be sufficient to maintain for several hours, in all parts of the room or mill, a temperature of from 118 to 125 degrees Fahrenheit.

THE RICE WEEVIL²²¹

Calandra oryzae Linnæus (Family Calandridæ)

Description.—The weevils are very dark-brown or nearly black, with two reddish spots at the base and two spots of the same color near the tips of the wing covers. The dorsum of the prothorax is densely pitted with minute round holes. The adults are about $\frac{1}{8}$ inch

²²¹This species may be distinguished from the granary weevil by the darker color and the spots on the elytra, the round instead of oblong punctures on the dorsum of the prothorax and by the presence of wings.

long, have wings and are thus able to fly. The larvæ or grubs are creamy white, robust and legless. The pupæ are white and about the size of the adults. The eggs are white, elliptical or slightly enlarged at one end and about 1-45 inch long.



Fig. 302.—The tulle billbug, *Sphenophorus discolor* Mann. Adults and eggs, natural size. (Original)

It has a long bill or snout which gives rise to the common name. The length averages 1 inch (Fig. 302).

Life History.—The life history of this species is not known. It breeds in the tules and the adults appear in the early spring and in a number of cases have injured growing grain.

Nature of Work.—With the long bill the weevil severs the heads of the growing stalks at the boot, thus killing the top. Fig. 303 shows the point of attack and a leaf removed to illustrate that the hole is extended entirely through the stalk.

Distribution.—The distribution of this weevil conforms to the tule-growing districts, especially in the central part of the State. It also occurs along the coast from San Diego to north of San Francisco.

Food Plants.—The tule (*Scirpus lacustris occidentalis* and other species) are the normal hosts, but barley, oats and wheat are also attacked.

Control.—This insect has proved to be injurious only on land reclaimed from or adjacent to the tule marshes. Though the damage may be quite serious, there are no known control measures which would warrant the cost of application.

Life History.—The life history is practically the same as that of the granary weevil.

Nature of Work.—The work is also the same as that of the granary weevil.

Distribution.—Like the grain weevil, this species is very common throughout the State.

Food.—Nearly all cereals, including barley, corn, oats, rice, wheat, etc., are attacked.

Control.—Control measures are the same as for the granary weevil.

THE TULE BILLBUG²²²

Sphenophorus discolor Mannerheim²²³ (Family Calandridæ)

(Figs. 302, 303)

Description.—The adult is dark brown with light markings on the lateral and ventral

²²²Smith, H. S., Mo. Bul. Cal. Hort. Com., II, pp. 619-621, 1913.

²²³*Sphenophorus pictus* Lec., commonly associated with this species, differs only in having white markings on the dorsum. It is but a color variety of *Sphenophorus discolor* Mann. and not a distinct species, according to Dr. E. C. Van Dyke.

THE SHOT-HOLE BORER OR FRUIT-TREE BARK-BEETLE

Eccoptogaster rugulosus (Ratzeburg) (Family Scolytidae)*(Scolytus rugulosus Ratzeburg)*

(Figs. 304-307)

Description.—The beetles are very small, nearly cylindrical in shape, black except the tips of the wing covers and the legs, which are cinnamon red. They are about $\frac{1}{16}$ inch long and one third as wide. The larvæ are slightly longer than the adults, white or dull yellowish-brown and slightly curved. The pupæ are whitish, becoming darker with age and about as large as the adults.

Life History.—In the spring, April and May, the adults of the overwintering brood begin to emerge through the small round "shot holes" about $\frac{1}{16}$ inch in diameter, which they make for this purpose. After mating the females make similar holes for reentering the bark, beneath which they carve large, straight, primary burrows in which, at various intervals along the sides, they make small pockets into which the eggs are deposited. As the eggs hatch the grubs make small secondary burrows at right angles to the primary burrow. These larval burrows are first very small, but become larger as the larvæ grow and extend them, until when the larvæ are fully matured, rounded cells are formed at the ends where pupation takes place. From these pupal cells the emergence holes are made through the bark. The eggs hatch in about three days, the larvæ mature in about twenty days and the pupæ in ten days, making the summer life cycle about twenty-three days. There are from two to three broods a year. The adults are usually more numerous during the late summer. The winter is passed in the larval and pupal stages under the bark. In southern California the writer secured a number of living adults in the burrows in January, indicating that some of the adults also survive the winter.



Fig. 303.—Barley stem showing slit and leaf removed to show holes made by the snout of the tule billbug, *Sphenophorus discolor* Mann. Enlarged twice. (After H. S. Smith. Photo by author)

Nature of Work.—The small, round holes in the bark of the trunks and limbs of the trees give the first clue to the presence of this pest. Upon removing the bark, the primary and secondary burrows or gal-

leries are disclosed (Fig. 305). These are made in the bark and cambium layer of the wood, causing great harm or death to the tree. It is also claimed that "the beetles destroy leaves by boring into the base of the buds at their axils."²²⁴ In general only unhealthy or weakened trees are attacked by the beetles, but it does appear that at times perfectly healthy trees also become infested and are eventually killed.



Fig. 304.—Bark of apricot tree showing exit holes and adults of the shot-hole borer or fruit-tree bark-beetle, *Eccoptogaster rugulosus* (Ratz.). Enlarged twice. (Original)

Distribution.—So far this species is recorded as limited in California to the deciduous fruit section adjacent to Ontario, San Bernardino County. As the beetle has been taken on nursery stock from that section, care should be taken to thoroughly inspect such stock to see that the pest is not introduced to other sections, as it is one which should be avoided if possible. It is unfortunate that nothing is being done to eradicate or check this beetle, for if it is allowed to continue unmolested it will soon be carried to all parts of the State.

²²⁴Sanderson, E. D., *Ins. Pests, Farm, Garden, Orchard*, p. 545, 1912.

Food Plants.—The following plants are attacked: apple, apricot, mountain ash, cherry, chokecherry, elm, hawthorn, Juneberry, nectarine, peach, pear, plum and quince. According to Quaintance,²²⁵ the plum is the preferred host, while the apple, peach and cherry are equally attacked. In California the apricot seems to be preferred equally as much as the plum.

Control.—Keeping the trees as healthy as possible and inspecting nursery stock to prevent introduction are the most important considerations with regard to this beetle. If infestation does occur, all trees which are badly attacked should be removed and burned and the others carefully pruned to remove all the infested parts possible. The application of a coat of carbolated white-wash (1 pint of 25% crude carbolic acid to 10 gallons of whitewash) is recommended.²²⁶ Prof. E. D. Sanderson²²⁷ also recommends the use of a thick soap wash containing a pint of crude carbolic acid to every 10 gallons, and quotes Prof. Gossard as having attained good results by applying early in spring, mid-summer and October a whitewash to which is added a small amount of table salt or Portland cement to make it stick. Prof. Gossard is also given as the authority for having obtained good results in killing the larvæ within their burrows by the application of a spray made by dissolving 3 pounds of naphtha soap in 3 gallons of hot water and adding 1 gallon of carbolineum. This is thoroughly agitated while still hot and diluted 1 to 4 of water for use.

Natural Enemies.—Natural enemies are given much credit for keeping down the attacks of this beetle in other states. A chalcid, *Chiro-pachys colon* Linn.²²⁸ is recorded as the most important.



Fig. 305.—Small apricot limb with bark removed to show the galleries made by the larvæ and adults and holes made by the adults of the shot-hole borer or fruit-tree bark-beetle, *Eccoptogaster rugulosus* (Ratz.). Enlarged twice. (Original)

²²⁵Yearbook U. S. Dept. Agric., p. 347, 1905.

²²⁶O'Kane, W. C., Inj. Ins., p. 242, 1912.

²²⁷Sanderson, E. D., Ins. Pests, Farm, Garden, Orchard, p. 546, 1912.

²²⁸Chittenden, F. H., Cir. 29, Bur. Ent. U. S. Dept. Agric., 1898.

THE CYPRESS TWIG-BORER²²⁹*Phlaosinus cristatus* Leconte (Family Ipidæ)

Description.—The beetles are light or dark brown in color, with darker head and prothorax. They are short, robust and quite small, averaging about $\frac{5}{32}$ inch in length and half as much in width.



Fig. 306.—Tree in neglected apricot orchard killed by the shot-hole borer or fruit-tree bark-beetle, *Eccoptogaster rugulosus* (Ratz.). Such a dead tree is an excellent breeding place for this pest. (Original)

Life History.—It is supposed that normally the adults breed in dead or unhealthy trees and only occasionally find their way to living tissue.²³⁰ The larval stage is passed usually in dead or decaying wood. During the spring and summer the beetles bore into the smaller twigs of the cypress, usually in the axils or forks, and so nearly sever the twigs that they either break off at the burrow or the tip dies. In this way trees and hedges are sometimes rendered unsightly and greatly injured.

They also burrow into unhealthy or dead trees, where the succeeding broods are reared.

Nature of Work.—The work consists in the making of shallow burrows two or three times the length of the beetle in the smaller twigs, causing many of them to break at the burrow and die. The beetles are usually found within the burrow and make the cause of the injury apparent at once. Dead or dying trees are normally attacked, but they often extend their work to perfectly healthy trees, and repeatedly attack the twigs of the latter.

Distribution.—This species is common throughout the southern and central parts of the State.

Food Plants.—Monterey cypress is injured most by the beetle, but the coast redwood is also reported as a host.²³¹



Fig. 307.—Adult of the shot-hole borer or fruit-tree bark-beetle, *Eccoptogaster rugulosus* (Ratz.). Enlarged five times. (Original)

²²⁹Another species, *Phlaosinus dentatus* Say, about the same size but usually lighter in color, works only on the California juniper in the State.

²³⁰Insect Life, V, p. 262, 1893.

²³¹Bul. No. 21, Bur. Ent., U. S. Dept. Agric., p. 7, 1899.

Control.—The control measures usually recommended consist in the removal and burning of all dead or dying trees which afford breeding places for the larvæ. Regular pruning of hedges and the burning of the trimmings have also given good results.

THE CYPRESS BARK-BEETLE

Phloeosinus cupressi Hopkins (Family Ipidæ)

(Fig. 308)

Description.—The adults are short, robust, dark-brown with prothorax and head nearly black, and about $\frac{1}{8}$ inch long. The larvæ are white and about $\frac{1}{8}$ inch long. The pupæ are white and as large as the adults.

Life History.—The adults appear in March and begin at once to make long galleries through the bark and into the sapwood. In these primary galleries the eggs are laid and the young grubs begin to make small secondary galleries from and at right angles to the primaries. The summer and winter is spent in these secondary galleries and in the spring the adults cut holes through the bark and emerge. After mating they begin to make new primary burrows and the life cycle is repeated.

Nature of Work.—The many small, round pinholes in the bark of the trunks and limbs of the trees make the presence of the beetle very easily known. If the bark is removed the primary and secondary galleries are very plain, as shown in Fig. 308. The work is in the sapwood and by its destruction the trees are soon killed. They normally attack only dead wood, but do work into the living tissues. Large drops of gum sometimes collect over the holes on the bark.

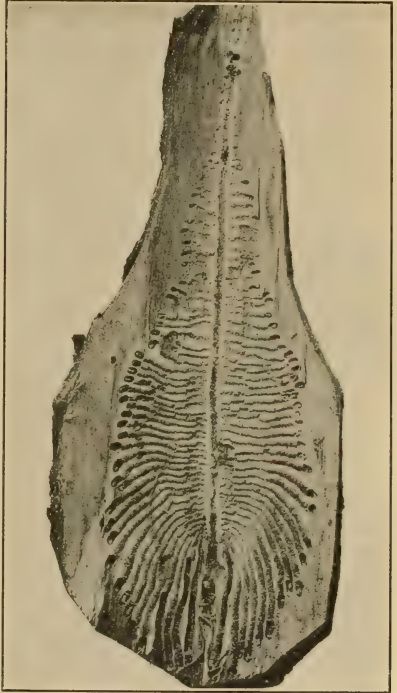


Fig. 308.—Piece of bark removed from a Lawson's cypress tree showing the work of the cypress bark-beetle, *Phloeosinus cupressi* Hopk. The adult entered the bark at the lower end and made the straight longitudinal primary gallery. At short intervals eggs were laid, which hatched into larvæ. These made the numerous transverse secondary galleries. At the ends of the older secondary galleries may be seen the pupal cells, from whence the adults made their exit holes. Natural size. Specimen taken at the Golden Gate Park, San Francisco, by Harold Compere. (Original)

Distribution.—The beetle occurs along the central coast in the counties adjacent to San Francisco Bay.

Food Plant.—The Lawson's cypress seems to be the preferred host and soon succumbs to the attacks of the beetle. The deodara cedar is also sometimes seriously injured.

Control.—The elimination of all infested trees and their destruction by fire is desirable to save those not yet attacked. During the winter months, when the beetle is in the larval stage, is the best time to do this. The presence of the beetle is easiest to ascertain in March and April, when the adults are emerging and reentering, as there are many holes made at that time.

THE LESSER SHOT-HOLE BORER

Xyleborus xylographus Say (Family Ipidae)

[*Xyleborus saeae* (Ratzeburg)]

(Figs. 309, 310)

Description.—The adults are very small, nearly cylindrical, dark brown or black beetles, about $\frac{1}{16}$ inch long and 1-35 inch wide. The head is situated directly under the prothorax, which is nearly half as long as the entire body (Fig. 309).



Fig. 309.—The lesser shot-hole borer, *Xyleborus xylographus* Say. Adults, enlarged six times. (Original)

Life History.—The larvæ spend the winter within their burrows and pupate early in the spring, so that adults begin to issue in March and April. These burrow into the heartwood of trees and deposit eggs in the tunnels. The eggs hatch into very small white or yellowish grubs, which work within the trees during the summer and winter.

Nature of Work.—The burrows made by the beetle are plainly shown in Fig. 310. They penetrate into the heartwood of the trees and the waste material is forced out of the burrows, like tiny piles of sawdust around the mouth. Trees become so riddled with the many tunnels that they are reduced to a mass of fine wood dust. While the beetles normally attack only dead or unhealthy trees, they are often responsible for killing trees which might not otherwise die. They may begin their attacks in an unhealthy spot and extend their work to perfectly sound portions.

Distribution.—The species is widely distributed throughout this State and the Pacific slope.

Food Plants.—Records in our office show this beetle to have been reared from apricot, prune, plum, cherry, lemon and orange trees. To this list Dr. Van Dyke adds the following: apple, beech, larch, pine, hickory, pear, oak, maple, hemlock and spruce.

Control.—The control of this pest is practically the same as recommended for the shot-hole borer or fruit-tree bark-beetle, *Eccoptogaster rugulosus*.

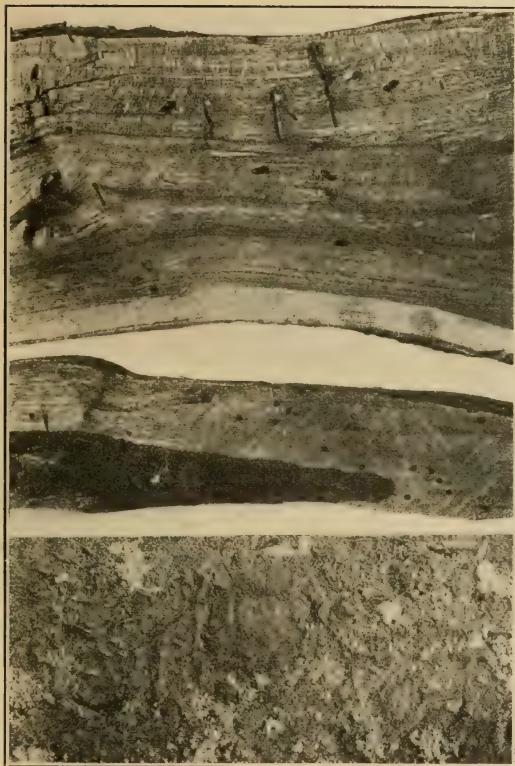


Fig. 310.—The work of the lesser shot-hole borer, *Xyleborus xylographus* Say, on an apparently healthy prune tree. At the left may be seen the piles of fine dust around the entrance holes, which are clearly shown in the middle. The right shows some of the burrows into the heartwood as well as a number of the beetles. Natural size. Specimens received from C. F. Collins, Tulare County. (Original)

THE ROSE SNOOT-BEETLE

Rhynchites bicolor Fabricius (Family Rhynchitidæ)

(Figs. 311, 312)

Description.—The beetles or weevils are bright red with the head, ventral surface, snout and legs black. The snout is one third as long

as the body. The females average about $\frac{1}{4}$ inch in length, while the males are considerably smaller. The eggs are light yellowish-white, oval, slightly larger at one end and 1-20 inch long. The grubs are white and legless.

Life History.—The winter is passed in the pupal stage in the soil, and the adults appear in April and May and at once begin to injure the roses, by punc-



Fig. 311. Rose buds showing the work and adults of the rose snout-beetle, *Rhynchites bicolor* Fab. Natural size. (Original)

turing the young buds with their long snouts. So many punctures may be made in a single bud as to prevent its opening, or to entirely spoil the flower if blooming is accomplished. They also make holes in the seed capsules and the tender fleshy stems, into which the eggs are inserted. Occasionally an egg is deposited in the flower, near the base of the petals. The grubs hatch in a very short time and feed within the seed capsule until fully developed, when, according to H. H. Knight of Cornell University, they leave the seed capsules and enter the ground for pupation and hibernation. There is but one brood a year.

Nature of Work.—The punctures made by the beetles in the spring are well illustrated in Fig. 311. In many cases the buds are killed



Fig. 312.—Egg of the rose snout-beetle, *Rhynchites bicolor* Fab., in natural position at base of the petals after the sepals had been removed. Enlarged twice. (Original)

outright, or stunted so that the flowers never open. In less serious cases the flowers may open, but the petals show the holes made in the buds. The leaves are also similarly attacked. Practically all of the injury is done between April 15th and May 15th in the interior valleys, but in the higher altitudes the period is about one month later.

Distribution.—The rose snout-beetle is widely distributed throughout the State.

Food Plants.—Though primarily a rose pest, attacking wild and cultivated species, this beetle also feeds upon the foliage of grapevines, oaks and raspberries.

Control.—Jarring the beetles into receptacles of oil or hot water is a very efficient means of controlling the pest in flower gardens. This should be carefully done each day until the adults no longer continue to appear. Poison sprays will also afford some relief, if the attacks are unusually serious.

DIPTERA (Order)

TWO-WINGED INSECTS

TRUE FLIES

This order is exceeded in the numbers of described species only by the order *Coleoptera* and possibly by the order *Lepidoptera* and is one of vast importance to health as well as to agriculture. Large numbers of the members feed upon decaying vegetable and animal matter, many are injurious to growing plants, while still others are predaceous and parasitic upon other insects and animals. When wings are present there are only two. The male coccids or scale insects and some of the may-flies are the only other insects thus characterized.

All have complete metamorphoses. The larvæ are legless and commonly known as maggots. They are usually headless, though some, as mosquito wrigglers, have well-developed heads. The pupa may or may not be enclosed in a tough larval skin, known as a puparium. The adults are commonly called flies, though this term is also given, usually with some prefix, to many other insects.

The mouth-parts are for piercing, lapping and sucking.

The life histories and habits of flies vary considerably. Most species lay eggs, while a few give birth to living maggots and others bring forth young already developed to the pupal stage. The latter flies are always parasitic. The feeding habits of the maggots differ greatly. A great many are terrestrial and feed upon decaying plant or animal matter or upon living plant or animal hosts, while others are aquatic in habits though they may have similar diets.

The control of this group is very difficult, due to the great productiveness of the females of some species and the secluded work of the larvæ. A contact spray is usually recommended for sucking insects, but is of little avail against the maggots, while poison-baits and sweet poisoned sprays are readily lapped up by adult flies and give some aid as control measures. The reduction of the number of maggots is only accomplished by the destruction of the adults. Carbon bisulfid is sometimes used to kill maggots in the soil, as in the case of root maggots.

To what extent natural enemies check the tremendous increase of flies is not well known. Predaceous insects prey upon the larvæ and adults, while internal parasites attack nearly all stages.

THE ALFALFA CRANE-FLY

Tipula simplex Doane (Family Tipulidæ)

(Fig. 313)

Description.—The adults are long-legged, slender-bodied insects of a light brown color. The females are wingless, while the males are winged and somewhat smaller, lighter in color and with longer and more delicate legs. The average length of the adult female is about $\frac{1}{2}$ inch.

The eggs are dark gray, oval and very small. The maggots are dirty white or light brown, very rough, with projections or breathing spiracles at the posterior end, and from $\frac{3}{4}$ to 1 inch long. Due to their tough skins, they are often called "leather jackets." The pupæ greatly resemble the larvæ in shape and color at first, but gradually assume

the color of the adults as they mature. The body segments are provided with sharp spines, which project backwards and by which the insects are able to wriggle to the surface when ready to emerge as adults.

Life History.—The eggs are deposited as deeply in the soil as the length of the female's abdomen will permit and are laid throughout the spring and summer. They soon hatch and the maggots, or "leather jackets," feed upon the roots of plants. They usually live in rather moist or even wet places, and remain in the larval stage during the winter and pupate in the spring. There is probably but one brood a year.

Distribution.—The insect is common in the central and northern parts of the State.



Fig. 313.—The alfalfa crane-fly, *Tipula simplex* Doane. Winged male and wingless female. Natural size. (After Carnes and Newcomer, Mo. Bul. Cal. Hort. Com.)

Food Plants.—The larvæ feed entirely upon the roots of plants, a variety being attacked. Serious damage has been reported in alfalfa and clover fields. They are most important as a pest in pasture lands, where they may destroy the grass over large areas. According to Professor R. W. Doane, in some regions, in particularly favorable years, the shortage of grass due to this insect has been so great that many of the cattle on the ranges have died of starvation.

Control.—The greatest amount of damage is usually done in fields which have long been seeded to alfalfa or clover, where the breeding has not been disturbed. Plowing and thorough cultivation will destroy most of the larvæ, which are either crushed or die for lack of sufficient moisture. The females, being wingless, are unable to migrate sufficiently to cause serious damage in one year. A cultivated crop once in two or three years, as a rotation with clover or alfalfa, is recommended when the destructiveness of the pest warrants strict remedial measures. On the ranges there is no remedy that would justify its cost.

Natural Enemies.—E. K. Carnes and E. J. Newcomer²³² report a tachina fly as parasite upon the larvæ.

THE CACTUS-FRUIT GALL-FLY

Asphondylia opuntiae Felt (Family Cecidomyiidae)

(Fig. 314)

Description.—The flies resemble mosquitoes somewhat because of their small size, long legs and slender shape. The bodies are gray and almost $\frac{1}{4}$ inch long. Fig. 314 shows the general characters very well. The larvæ are nearly cylindrical, white and $\frac{3}{16}$ inch long. The puparia

²³²Mo. Bul. Cal. Hort. Com., I, p. 279, 1912.

are white at first, but soon become light brown and are about the same length as the maggots.

Life History.—The life history of this insect has not been studied. The winter is probably passed in the pupal stage in the soil or in the fruit. The eggs are evidently laid on the outside of the fruits when the latter are quite small and the maggots upon hatching enter the



Fig. 314.—The cactus-fruit gall-fly, *Asphondylia opuntiae* Felt. Cactus fruit showing pupal cases and holes where adults have issued. Adults in upper right corner, enlarged three times. Fruit natural size. Specimens collected at Ventura by S. H. Essig. (Original)

pulp, riddling it with holes. Hundreds may infest a single small fruit. Pupation takes place in the burrow just beneath the outer skin. When ready to change to adult the pupa cuts a round hole through the skin and wriggles from one half to three fourths its length outside before the puparium breaks and the fly emerges. The illustration (Fig. 314) shows the large number of pupæ cases still adhering to the fruits.

Nature of Work.—The first evidences of the presence of this fly is the prematurely yellowing and ripening or the stunting and deforming of the fruit. By the time the pupæ begin to show through the skin the fruit is entirely destroyed. Because of the possibilities of growing cactus fruits in the southern part of the State, this fly is of considerable economic importance and may become more so as the industry is developed.

Distribution.—The cactus-fruit gall-fly has a wide range throughout the southern part of the State. It has been reported from Los Angeles southward by Hunter, Pratt and Mitchell.²³³ In the spring of 1914

²³³Bul. No. 113, Bur. Ent., U. S. Dept. Agric., pp. 34-35, 1912.

S. H. Essig collected large quantities of seriously infested fruit in Ventura County.

Food Plants.—The fruits of various species of *Opuntia* are attacked.

Control.—Control measures for this pest have not been worked out and will undoubtedly be difficult. The entire elimination of the native food plants should precede any commercial plantings of cactus.

THE HESSIAN FLY

Phytophaga destructor (Say) (Family Cecidomyiidae)

[*Mayetiola destructor* (Say)]

(*Cecidomyia destructor* Say)

(Fig. 315)

Description. — This insect, when fully developed, is a small brown fly, about $\frac{1}{10}$ inch in length. The eggs are about 1-50 inch long, cylindrical and shining red. The maggots are greenish-white in color and work between the sheaths and stems of the host. The puparia are rich brown and located in the stems or among the roots at the bases of the plants.

Life History. — The adults appear in the fall and deposit their eggs upon the stems and leaves of the young growing wheat as soon as it is well above the ground. The larvæ work between the blade-sheath and stem during the fall and winter, changing to puparia in the spring and to adults a little later. These adults, known as the spring brood, lay eggs in the growing stalks, weakening and causing them to fall. After the grain is cut the maggots remain in the stubble,

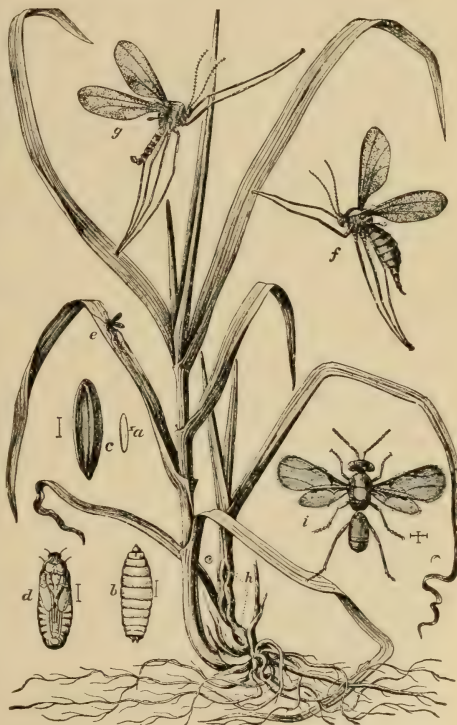


Fig. 315. — The Hessian fly, *Phytophaga destructor* (Say). Healthy wheat stalk at left and infested stalk at right; a, egg; b, larva; c, puparium or "flaxseed"; d, exposed pupa; e, adult female laying eggs; f, female; g, male; h, puparium or "flaxseeds" in natural position between leaves and stalk; i, parasite (*Merisus destructor*). All greatly enlarged excepting e, which is about natural size. (After Riley, Burgess and Forbes)

transforming into adults, known as the fall brood, which lay their eggs upon the young growing wheat.

Nature of Work.—The maggots work in the stems, usually near the ground, and either kill or so stunt the plants that little or no grain is produced. Infested fields appear yellowish and look very unhealthy.

Distribution.—This insect was introduced into the State many years ago. It is recorded as occurring in the San Francisco Bay region and south along the coast to Monterey Bay,²³⁴ where it is still quite common, but does little or no damage.

Food Plants.²³⁵—Wheat is most seriously injured by this pest, and the damage done to that crop in the central wheat-growing states has been great. It also works upon *Agrostis*, brome grass (*Bromus ciliatus*), quack grass and American wild rye (*Elymus americanus*).

Control.—Fortunately the ravages of this fly in California have not been great, and it is to be hoped that it will never become a serious pest here. Control is extremely difficult, consisting in burning and plowing under the stubble as soon as the wheat is cut and planting as late in the fall as possible. Early trap crops of wheat are also planted about August. Such crops attract the flies, and after the eggs are laid they are plowed under and destroyed.

Natural Enemies.—Parasites also play some part in the control of the pest. In the Eastern States the parasite, *Merisus destructor* Say, works upon it. The internal parasite, *Semiotellus destructor*, has been bred from the fly in California.

SYRPHIDÆ (Family)

FLOWER, HONEY OR SWEAT FLIES

Always among the plant lice are to be found flat, sticky-looking maggots, which are decidedly pointed at one end and do not have distinct head, eyes or legs. These so-called "worms" are the larvæ or maggots of flies belonging to the family *Syrphidæ*, which are commonly called syrphid or flower flies. The larvæ vary from the very minute first-hatched maggots to nearly an inch in length, according to the species. They may be dark green, brown, orange, very light or nearly black in color. Those feeding upon plant lice, and herein described, are green with a longitudinal stripe on the dorsum. The mouth is situated at the small end, and all of the food is obtained by puncturing the body walls of the lice and then sucking out the contents. This operation is easily observed in the field. The maggot, firmly supported by the large posterior end, raises itself up and begins to blindly move its mouth end about in quest of food. If it touches a plant louse it immediately lifts it into the air and sucks it dry. This is very rapidly repeated, with very disastrous results to the lice. When the larva is full grown it seeks some sheltered spot in which to pupate. This may be accomplished on the stems or upon the surface of a leaf. The puparium is a long, roundish, or oval body of various colors, showing no signs of life. The fly removes one end (the operculum) of the puparium to escape. The adults are of various colors, but those most

²³⁴Bul. No. 16, n. s., Bur. Ent. U. S. Dept. Agric., 1898.

²³⁵Jr. Ec. Ent. II, p. 231, 1909.

familiar are usually dark, with transverse yellow bands across the abdomen. They are very swift fliers and are often mistaken for bees or wasps. They are common around flowers, feeding upon the nectar, and from this habit get the names "flower or honey flies." On hot days they are sometimes very numerous and are called "sweat flies" in the Eastern States. They deposit their rather long, whitish eggs singly upon leaves and twigs which are infested with plant lice, and these give rise to the green larvæ.

There are many groups with entirely different food habits. Some are destructive to plant life, while most are of no particular economic importance.

While some of these flies do much to prevent the spread of plant lice, they are in turn preyed upon by other insects. Ants, which foster and protect the plant lice, kill and carry off the syrphid larvæ in large numbers and greatly reduce their efficiency.

There are many other enemies, which also prey upon all stages of the syrphid flies. The larvæ and pupæ are heavily parasitized by internal hymenopterous parasites, especially of the genus *Anomalon*,²³⁶ including, in this State, *A. syrphicola* Ashm., *A. orbitalis* Ashm., *A. xanthopsis* Ashm., and *A. maculifrons* Cr. The adults are often attacked by a fungus (*Empusa* sp.), which kills great numbers of them.

There are many common species in California and it is impossible to include all here, so only a few representative destructive and beneficial forms are given.

THE OBLIQUE SYRPHID FLY

Allograpta obliqua Say

(Fig. 316)

Description.—This is one of the smaller syrphid flies, being seldom over $\frac{1}{4}$ inch long. The body is slender; eyes, dark red; face, yellow with dark median line; antennæ, amber-brown; thorax, iridescent green; scutellum and legs, light yellow; abdomen, dark with four transverse yellow bands on the dorsum, and yellow longitudinal markings at the base of the amber or dark brown abdominal tip.

Distribution.—This is one of the most widely distributed and common species found in the southern part of the State, being present in practically every locality. It is rare in the central and northern sections, as noted by W. M. Davidson.

Hosts.—The larvæ of this fly work upon a great number of lice, and adults have been reared from those feeding upon the oat aphid, *Aphis avenæ* Fab., the black citrus plant louse, *Toxoptera aurantia* Koch, the melon aphid, *Aphis gossypii* Glover, and the destructive pea aphid, *Macrosiphum pisi* (Kalt.).



Fig. 316.—The oblique syrphid fly, *Allograpta obliqua* Say. Enlarged five times. (Author's illustration, P. C. Jr. Ent.)

²³⁶Insect Life, III, p. 460, 1891.

THE LEMUR SYRPHID

Baccha lemur Osten Sacken

(Fig. 317)

Description.—The adult is dark gray or nearly black, with a very slender body and a large black spot near the middle of each wing. It averages about $\frac{1}{2}$ inch in length.



Fig. 317. — The lemur syrphid, *Baccha lemur* O. S. Adult, enlarged twice. (Original)

Life History. — Practically nothing is known concerning the life history of this insect. The writer reared large numbers of adults from twigs infested with the yerba-santa mealy bug, *Pseudococcus yerba-santæ* Essig, upon which the larvæ were evidently feeding.

Distribution.—The author collected large numbers of this fly in Ventura County. It occurs commonly in the southern part of the State, but is rare elsewhere, according to W. M. Davidson.

Host.—The yerba-santa mealy bug, *Pseudococcus yerba-santæ* Essig, and other early bugs are hosts of this fly.

THE DRONE FLY

Eristalis tenax Linnaeus

(Fig. 318)

Description.—The adults are large yellowish-brown flies, resembling very much the drones of the common honey bee. The body is dark with yellowish-brown markings upon the abdomen, which is also covered with short, fine, yellowish hair. The head, thorax and legs are covered with longer hair of the same color. The wings have brown stains near the middle. The length is about $\frac{1}{2}$ inch. The larvæ are brownish, and because of the long anal breathing segment are known as rat-tail maggots. This long tube allows the maggots to breathe while imbedded in liquid filth.

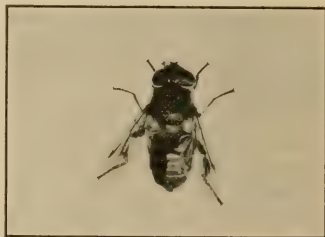


Fig. 318. — The drone fly, *Eristalis tenax* Linn. Adult, enlarged twice. (Original)

Life History.—The eggs are laid about non-sanitary toilets, sewer outlets and similar filthy places, where the hatched larvæ may feed and develop. The adults are said to be of value because of their aid in the pollenization of composite and other flowers. They are very busy workers and exceedingly active on the wing.

Distribution.—Throughout the State—a very common fly.

THE NARCISSUS BULB-FLY²⁸⁷*Merodon equestris* Fabricius²⁸⁸

(Figs. 319, 320)

Description.—The adults are large two-winged flies from $\frac{3}{8}$ to $\frac{1}{2}$ inch long. They are black and usually banded with yellow or gray, much resembling a bumble bee. The entire body is very hairy. The eggs are very small, oval and white. The larvæ or maggots are dirty white or yellow, legless and from $\frac{1}{2}$ to $\frac{3}{4}$ inch long. At the posterior end is a



Fig. 319.—The narcissus bulb-fly, *Merodon equestris* Fab. Upper left is larva removed to show shape and general appearance, lower is larva *in situ* in narcissus bulb. Enlarged three times. (After Childs, Mo. Bul. Cal. Hort. Com.)

projection bearing two spiracles for breathing. The mouth-hooks and anterior spiracles are not so easily located. The pupæ are elongate, grayish-brown, distinctly segmented, with posterior projecting spiracles still visible.

Life History.—The winter is passed in the larval stage within the bulbs in the soil. Pupation takes place in the old burrow or in the soil, in the spring, and the adults appear in early summer and deposit their eggs on the plants near the base of the leaves, or on the bulbs if they

²⁸⁷Childs, Leroy, Mo. Bul. Cal. Hort. Com., III, pp. 73-76, 1914.

²⁸⁸A small black hymenopterous insect commonly known as the cattleya fly, *Isosoma orchidearum* Westwood, belonging to the family *Eurytomidae*, has recently been reported by L. A. Whitney as attacking orchids in a greenhouse in San Francisco. The larvæ feed within the bulbs, which are greatly distorted or may even be entirely destroyed. (Mo. Bul. Cal. Hort. Com., pp. 483-485, 1914)

are exposed above ground. The larvæ eat through the tender scales to the heart, where they feed and remain during the winter. There is but one brood a year.

Nature of Work.—The maggots usually feed in the center of the bulbs, and their presence is often quite difficult to detect. One method is to squeeze the bulbs near the neck when they are dug, and if they give to the pressure of the hand they are almost certain to be hollowed out by the maggots. When cut open the bulbs appear as represented in Fig. 319. There is usually but one maggot in a bulb, but occasionally two or three may be found in one plant. In some localities the insect often proves very serious and causes great loss to bulb growers.

Distribution.—The maggots of this fly have often been taken in quarantine in shipments of bulbs from Europe. The insect has become established in the San Francisco Bay region and has been taken in Marin, Alameda and Santa Cruz counties. It is also abundant and quite destructive in British Columbia, in the vicinity of Vancouver.²³⁹



Fig. 320.—Adult narcissus bulb-fly, *Merodon equestris* Fab. Enlarged three times. (After Childs, Mo. Bul. Cal. Hort. Com.)

Food Plants.—The following lily bulbs are known to be hosts of the fly: *Amaryllis*, daffodil, *Eurycles*, *Galtonia*, *Hippeastrum*, hyacinth (cultivated and wild), *Narcissus*, *Saltonia*, *Scilla nuttoris*, tulip (rarely) and *Vallota*.

Control.—Control measures, though affording only partial relief, are well worth observing, as they often give very satisfactory results. If bulbs do not grow in the spring they should be dug and destroyed, as well as all unhealthy looking plants. All should be dug in the summer and carefully sorted to eliminate those infested. Bulbs may be steeped from twenty-four to forty-eight hours in lukewarm water, care being taken to see that the water does not get cold and the bulbs become chilled. Practically all of the larvæ may be drowned in this way. After soaking, the bulbs should be carefully dried. Capturing adults early in the spring with a net is also recommended. No infested bulbs should ever be planted.

²³⁹Treherne, R. C. Proc. Ent. Soc. Brit. Columbia, No. 4, n. s., pp. 31-32, 1914.

THE AMERICAN SYRPHID FLY

Syrphus americanus Wiedemann

(Fig. 321)

Description.—In general this species greatly resembles *Syrphus pyrastris* (Linn.) in shape and color, though it is somewhat smaller. The eyes are dark reddish-brown; face, amber yellow with a dark band in the middle extending from the base of the antennæ to the mouth; antennæ, black, with dorsal arista; thorax, iridescent green, covered with fine, long hair; legs, amber with bases dark; abdomen, rich, shiny black with one broken and three continuous transverse yellow bands on the dorsum.

Distribution.—This syrphid is very common in all sections of the State.

Hosts.—The larvæ feed upon a great number of plant lice, including the black peach aphid, *Aphis persicæ-niger* Smith, the melon aphid, *Aphis gossypii* Glover, the green apple aphid, *Aphis pomi* DeG., the green citrus plant louse, *Macrosiphum citrifolii* Ashm., the destructive pea aphid, *Macrosiphum destructor* (Kalt.), and the black citrus plant louse, *Toxoptera aurantiæ* Koch.



Fig. 321.—The American syrphid fly, *Syrphus americanus* Wied. Adults, enlarged three times. (Original)

THE LARGE SYRPHID FLY

Syrphus pyrastris (Linnæus)[*Catabomba pyrastris* (Linnæus)][*Lasiophthicus pyrastris* (Linnæus)](*Musca pyrastris* Linnæus)

(Fig. 322)

Description.—This is one of the larger syrphid flies, being nearly $\frac{1}{2}$ inch long. The compound eyes occupy most of the head and are dark Indian-red or brown. The face is yellow and hairy, with median dark line; the antennæ are black with long dorsal arista; the thorax is iridescent dark blue or green and covered with long, fine hairs; the scutellum is the same color as the mesothorax; the coxæ are dark; the femora, dark with tips light; the tibiæ, amber or yellowish, slightly darker at tips; the tarsi, dusky; the abdomen is velvety black with three pairs of marginal curved transverse bands on the dorsum. These bands do not come together in the middle, and so really form six broken bands. In the females they are sometimes absent. The eggs are very small and white. The larvæ, when full-grown, are nearly $\frac{3}{4}$ inch long and vary from light green to light brown in color. The puparia are brown

Distribution.—This is an exceedingly common species found all over the State.

Hosts.—The larvæ appear to make little or no distinctions as to aphid species and feed upon a great many, among which are: the green citrus plant louse (*Macrosiphum citrifolii* Ashm.), the black citrus



Fig. 322. — The large syrphid fly, *Syrphus pyrastris* (Linn.). Adults, enlarged twice. (Original)

plant louse (*Toropectera aurantiae* Koch), the melon aphid (*Aphis gossypii* Glover), the black peach aphid (*Aphis persicae-niger* Smith), the cabbage aphid (*Aphis brassicae* Linn.), the oat aphid (*Aphis avenae* Fab.) and the mealy plum plant louse (*Hyalopterus arundinis* Fab.).

TACHINIDÆ (Family)

THE TACHINA FLIES

This is one of the most beneficial families of insects, because of the parasitic habits of the larvæ upon destructive caterpillars, grasshoppers, bugs, beetles, sawflies, etc.

The adults vary greatly in size and are usually grayish with striped and very hairy bodies. They become very active on hot days. The eggs are usually white and stuck to the living larvæ, upon which the maggots are to feed. Upon hatching, the larvæ bore through the skin of the host, nourishing themselves throughout their development upon the internal tissues, avoiding the destruction of the vital organs until ready to pupate. When the host is destroyed they usually leave the old carcass and form hard, brown puparia near the surface of the ground. The adults issue from these in a very short time. Breeding



Fig. 323.—A tachina fly, *Phorocera saundersii* Williston reared from caterpillars of the variegated cutworm, Mendocino County, Sept. 14, 1914. The flies are dark metallic blue; the females averaging $\frac{1}{4}$ inch and the males 3-16 inch in length. The specimens were determined by W. R. Walton through the kindness of Prof. J. M. Aldrich. (Original)

is rapid, there being, in some species, several generations each year. The reproductive habits are varied. Some lay large, flat, whitish eggs on the host, the larvæ emerging below and entering the host without disturbing the empty egg-shell; others lay large numbers of minute eggs on the foliage, which are swallowed with the plant tissues by the host in feeding; still others puncture the integument

of the host with a sharp ovipositor and introduce a larva already hatched. While these are believed to be the principal ways by which the larvæ gain access to the interior of the host, several other methods have been noted.

THE SPINY TACHINA FLY

Paradejeania rutilioides Jænnicke

(Fig. 324)

Description.—The adult of this species is large, measuring nearly $\frac{3}{4}$ inch in length. The abdomen is especially large and covered with long black hairs. The face is black with a silvery luster; eyes, dark brown; antennæ, black; thorax, black with yellow margin and scutellum; basal half of the abdomen, yellow with a longitudinal median line and the apical half black; wings, dusky throughout with yellow base; legs, black.

Distribution.—This species occurs throughout the central and southern parts of the State.

Hosts.—Caterpillars of various species are the hosts. How the larvæ enter the host is unknown.



Fig. 324.—The spiny tachina fly, *Paradejeania rutilioides* Jæn. Adult female, enlarged twice. (Author's illustration, Mo. Bul. Cal. Hort. Com.)



Fig. 325.—The robust tachina fly, *Peleteria robusta* Wied. Adult female, enlarged twice. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

THE ROBUST TACHINA FLY

Peleteria robusta Wiedemann

(Fig. 325)

Description.—The adults are about $\frac{1}{2}$ inch long. The face is white; antennæ, brown and black; eyes, brown; thorax, metallic black and dull grayish along the sides; the abdomen, brick-red or yellowish with black dorsal and median longitudinal stripe.

Distribution.—The robust tachina fly is common throughout the entire State, having been reported from Lake, Santa Cruz, Calaveras, Los Angeles and San Bernardino counties.

Hosts.—This species works upon the larvæ and pupæ of the tussock moth (*Hemcrocampa vetusta* Boisd.) and other moths. Nothing, however, is known about the habits of egg-laying and the entrance of the larvæ into the host.

THE TUSSOCK MOTH TACHINA

Tachina mella Walker

(Fig. 326)

Description.—The flies appear dark gray in color. The eyes are brown; face, white; thorax, black with dull gray markings; halteres, white; abdomen, black with regular gray spots on the sides of the dorsum; legs and antennæ, black. The females are $\frac{3}{8}$ inch long and the males considerably smaller, as shown in Fig. 326.

Distribution.—The tussock moth tachina occurs throughout the entire State and is quite a common species.



Fig. 326.—The tussock moth tachina, *Tachina mella* Walker. Male and female, enlarged three times. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

Hosts.—This fly preys upon the California tussock moth (*Homocampa vctusta* Boisd.), the forest tent-caterpillar (*Malacosoma disstria* Hubn.) and other species of *Malacosoma*.

ANTHOMYIDÆ (Family)

ROOT-MAGGOTS AND LEAF MINERS

The adults are rather small or moderately large, somewhat resembling house flies. The bodies are usually non-metallic and clothed with few or many rather stiff hairs. The first posterior cell of the wings is broadly open. The adults are common about houses and gardens. The maggots usually feed upon decaying vegetable matter, but those of a number of species attack living plant tissue and are serious garden pests.

THE BEET OR SPINACH LEAF-MINER

Pegomyia vicina Lintner

(Figs. 327-331)

Description.—The flies are gray with the front of the head white. The entire body is sparsely covered with stiff black hairs. The length averages slightly less than $\frac{1}{4}$ inch. The eggs are elongate-oval, being about three times as long as wide, ivory white with surface beautifully sculptured, as shown in Fig. 327. They are about 1-20 inch long. The maggots are white or yellowish-green if feeding. The mouth hooks are black. The spiracles are brown and arranged in two sets of three each, near the top of the blunt posterior end. The length of the full-grown

maggots averages about $\frac{1}{2}$ inch. The puparia are dark reddish-brown, regularly oval and nearly $\frac{1}{4}$ inch long.

Life History.—The winter is spent in the pupal stage one or two

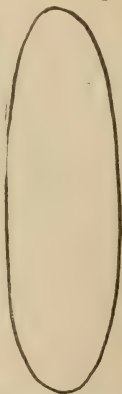


Fig. 327.—The beet or spinach leaf-miner, *Pegomyia vicina* Lintner. Eggs on beet leaf at the left in a very characteristic group of eight, enlarged nearly three times. Outline of egg and portion of sculptured surface at the right, very greatly enlarged. (Original)

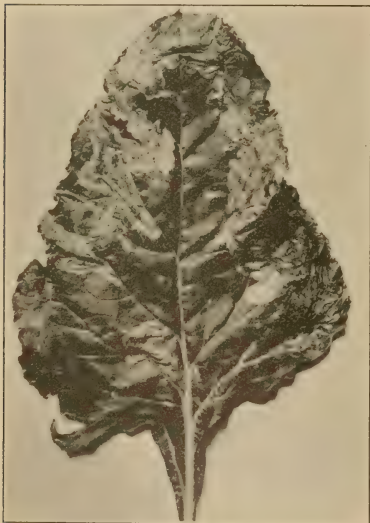


Fig. 328.—Leaf of a sugar beet showing the mines made by the maggots of the beet or spinach leaf-miner, *Pegomyia vicina* Lintner. Reduced. (Original)

inches below the surface of the ground. The adults emerge in the spring and lay their eggs on the undersides of the leaves. They are usually deposited in groups of four or eight, but there are sometimes but one or two in a mass. They are fastened by the sides and are arranged in irregular rows side by side. They hatch in less than a week and all of the

maggots enter the leaf tissues near the same place and work together just under the upper epidermis, forming a long winding mine, or more often a large blotch. Within one or two weeks the maggots are full-grown. They then leave the mines and drop to the ground, where the pupal stage is passed usually within two inches of the surface. Occasionally a pupa may be found within the mine. The pupal stage requires from ten days to three weeks. The adults mate and immediately begin egg-laying. There appear to be several rather uneven broods in this State. The adults of the first brood begin to mature by the first of June and breeding continues throughout the summer. Practically all stages are to be found from June until the first of October, indicating two or three overlapping broods.

Nature of Work.—The mines are made between the upper and lower epidermis of the leaves and the chlorophyll is completely destroyed, the mines or blotches soon turning white and later yellow or brown. Many of the leaves are completely killed by the attacks and any grown for greens, as spinach, are completely ruined for market if only slightly infested. The maggots are easily located in the mines by feeling or by holding the leaf to the light.

Distribution.—This fly is very common at Berkeley, Oakland, Alameda and other sections around the San

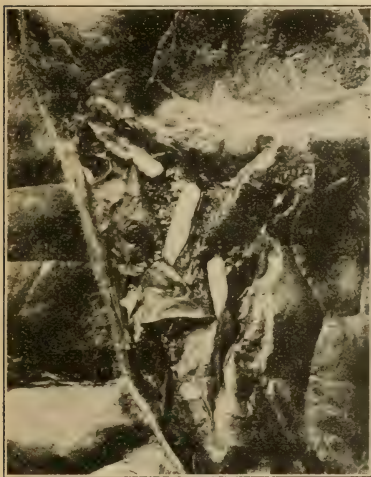


Fig. 329.—Epidermis above mine on a beet leaf broken to show the maggots of the beet or spinach leaf-miner *in situ*. Enlarged twice. (Original)

Francisco Bay. It was first reported in the State from Alameda, Castroville and Watsonville in 1893.²⁴⁰ The distribution is probably quite wide.

Food Plants.—The leaves of all kinds of beets and of spinach and lambs-quarters are attacked.

Control.—Control measures are the same as recommended for the radish maggot.



Fig. 330.—One and one half inches of the upper soil removed to show the puparia of the beet or spinach leaf-miner. Enlarged twice. (Original)



Fig. 331.—Adult of the beet or spinach leaf-miner, *Pegomyia vicina* Lintner. Enlarged four times. (Original)

²⁴⁰Howard, L. O., *Insect Life*, VII, pp. 379-381, 1895.

THE SEED-CORN MAGGOT

Phorbia fusciceps (Zetterstedt)[*Pegomyia fusciceps* (Zetterstedt)]*Aricia fusciceps* Zetterstedt)*(Anthomyia zeæ* Riley)*(Chortophila cilicrura* Rondani)

(Figs. 332, 333)

Description.—The fly is about $\frac{1}{5}$ inch long or nearly the same size as the ordinary house fly and light gray in color. The adult may be

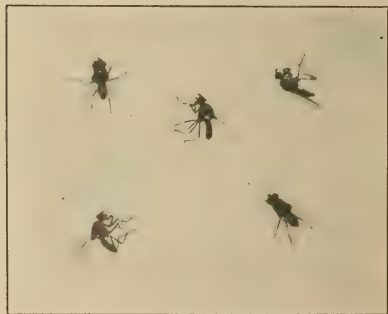
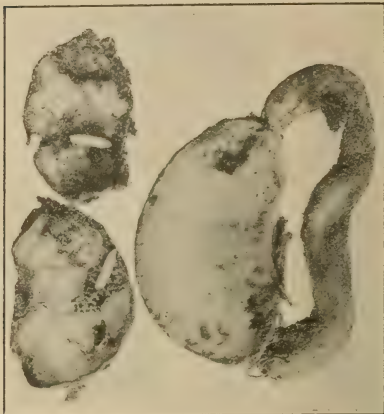


Fig. 332.—The seed-corn maggot, *Phorbia fusciceps* (Zett.). Top picture shows maggots and their work on young lima beans; bottom shows adults. Slightly enlarged. Specimens received from H. V. M. Hall, San Diego. (Original)

peas, potato, radish, sweet potato and turnip are attacked.

separated from related species by a row of short, nearly equal, hairs on the inside of the hind tibiae.²⁴¹ The maggot is nearly cylindrical, being largest at the posterior end, white or yellowish and about $\frac{1}{4}$ inch long. The puparium is oval, dark brown, with two projections on the anterior and several projections on the posterior end.

Life History. — The life history of this species is practically the same as that of the radish maggot.

Nature of Work. — The maggots work in the soil upon the sprouting seeds and either prevent growth of the plants or so injure them as to produce only a stunted, sickly plant.

Distribution.—The fly has been received from San Diego and Santa Barbara counties and reared from onions from the San Francisco Bay region. It probably also occurs elsewhere in the State. It is common throughout the United States.

Food Plants.—The sprouting seeds or young plants of beans (lima and other varieties), beets, cabbage, corn, mustard, onions,

²⁴¹Sanderson, E. D., Ins. Pests Farm, Garden and Orch., p. 321, 1912.

Control.—The control of this pest is the same as for the western radish maggot.



Fig. 333.—Puparia and adults of the seed-corn maggot, *Phorbia fusciceps* (Zett.). Enlarged three times. (Original)

THE WESTERN RADISH MAGGOT²⁴²

Phorbia planipalpis (Stein)
[*Pegomyia planipalpis* (Stein)]
(*Chortophila planipalpis* Stein)

(Figs. 334-339)

Description.—The flies are rather robust, dark blue or black and covered with many large black hairs, which give them the appearance of the tachina flies. The length averages $\frac{3}{8}$ inch from the face to the tip of the wings. The females have two continuous and two broken



Fig. 334.—Radishes showing the work of the Western radish maggot, *Phorbia planipalpis* (Stein). Natural size. (Original)

longitudinal lines on the dorsum of the prothorax. In the males the median black stripe on the dorsum of the abdomen is continuous. The eggs are long and slender, slightly curved, pure white with very fine longitudinal depressions and $\frac{1}{16}$ inch long. The maggots vary from white to yellow and when full grown are from $\frac{1}{4}$ to $\frac{3}{8}$ inch long. They are distinctly segmented, truncate at one end and pointed at the other.

²⁴²The cabbage maggot, *Phorbia brassica* (Bouché) does not occur in California according to the recent findings of Prof. J. M. Aldrich, who has kindly identified all of the material for me. All previous mentions of this species probably refer to the western radish maggot.

The pointed end is dusky and there are two minute black spiracles on the truncate end. The puparia are regularly oval, distinctly segmented, from light reddish-brown to dark brown in color and average $\frac{1}{4}$ inch in length.

Life History.—The winter is passed in the adult and pupal stages. The hibernating adults and those transforming from the pupæ begin to emerge in the spring and to lay eggs upon the host plants. They are deposited singly or in small, loose masses upon the young leaves near the crown of the host or upon the root, if it protrudes above the ground.



Fig. 335.—Longitudinal sections of radishes, showing work, maggots and puparia of the Western radish maggot, *Phorbia planipalpis* (Stein). Natural size. (Original)

The young maggots, on hatching, burrow directly into the roots, completely ruining them for market purposes. The entrances to the burrows soon become darkened and usually juices exude during the earlier periods of their work. When full-grown the maggots pupate in the burrows or in the soil near the roots. Rarely the pupæ have been found among the green leaves. The adults of the first or second brood begin to issue in August and September, and the eggs for another brood are laid immediately. On September 10th the writer was able to take all stages of maggots, eggs, pupæ and adults. There appears to be several broods a year.

Nature of Work.—The illustrations (Figs. 334, 335, 336) show well the work of this fly. Burrows are made through portions of or the entire roots, either killing the plants outright or making them unfit for market purposes.

Distribution.—This fly is quite common in the San Francisco Bay region, having been collected by E. M. Ehrhorn in August, 1901.²⁴³ The writer has found it abundant in Berkeley, in August and September, 1914. Professor R. W. Doane reports it at Carmel, Monterey County.

Food Plants.—The author has reared this maggot from the following plants: cabbage, cauliflower, radish, rutabaga and turnips. To this list J. A. Hyslop adds lupines and field peas.²⁴⁴

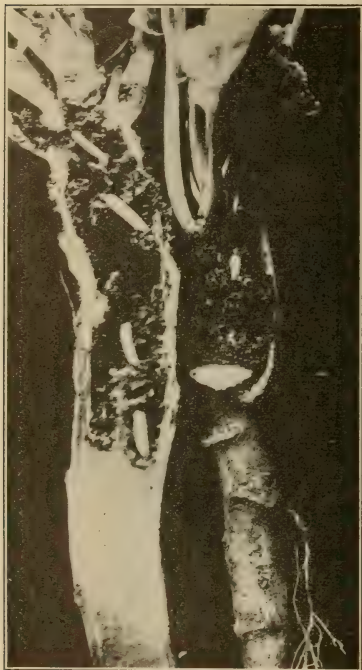


Fig. 336.—Longitudinal section of cauliflower plant and young cabbage plant showing work and maggots of the Western radish maggot, *Phorbia planipalpis* (Stein). Natural size (Original)

Control.—The control of such a pest is extremely difficult and relief measures are usually employed as preventatives. Among the most effective remedies used for the cabbage maggot, a very close relative, are the placing of sand, soaked in kerosene, around the bases of each plant as soon as transplanted or well up in the field. This is to prevent egg-laying by the female. A weak solution of carbolic acid emulsion sprayed repeatedly over the plants will keep the flies away. Fertilizers, such as kainit, nitrate of soda and superphosphate, applied at the rate of from 1,000 to 1,500 pounds of kainit, 100 pounds of nitrate of soda, or 200 pounds of superphosphate per acre are recommended. Gas lime, applied around each plant, is claimed to afford some protection.

Carbon bisulfid, though an expensive remedy, is effectual. A special tarred card, placed around the base of cabbage and cauliflower plants, prevents the flies depositing their eggs upon the stem.

Plowing and thorough cultivation are recommended as giving excellent results in the control of this pest. A badly infested field should be thoroughly plowed and cultivated as early as possible to destroy the pupæ.

Natural Enemies.—Of the internal parasites bred from this species there are reported *Aphareta* sp., *Polypeza* sp.²⁴³ and *Holaspis* sp.²⁴⁴ The author has reared as many as eleven individuals of an undetermined parasite from a single pupa.

²⁴³Bul. No. 66, pt. VII, Bur. Ent., U. S. Dept. Agric., p. 95, 1909.

²⁴⁴Bul. No. 95, pt. VI, pp. 105-108, 1912.



Fig. 337.—Eggs of the Western radish maggot, *Phorbia planipalpis* (Stein). At left as they are deposited on the radish, enlarged twice; at the right an outline drawing and portion of the sculpturing on the surface, greatly enlarged. (Original)

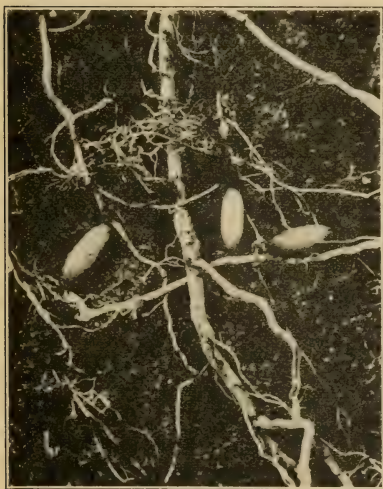


Fig. 338.—Puparia of the Western radish maggot, *Phorbia planipalpis* (Stein), in the soil at base of a young cabbage plant, previously attacked by the maggots. Enlarged twice. (Original)



Fig. 339.—Adult of the Western radish maggot, *Phorbia planipalpis* (Stein). Side view, enlarged twice. (Original)

THE SPOTTED ROOT FLY²⁴⁵*Euresta notata* Wiedemann (Family Ortalidæ)

Description.—The flies are slightly over $\frac{1}{8}$ inch long, beautiful, metallic-green in color with eyes dark brown. The wings are transparent with a distinct black spot near the middle of the front margin and a similar spot near the tip of each. The maggots vary from white to dusky brown, the blunt end being often darker than the rest of the body. They are about $\frac{1}{4}$ inch long when fully matured. The puparia are dark brown, rather slender-oval and about $\frac{3}{16}$ inch long.

Life History.—The eggs are usually laid in the tissues of injured or damaged fruits and vegetables, and while the maggots work principally upon such tissues they are often found in sound and living portions and occasionally in apparently uninjured fruits. The pupæ are found in the decayed hosts or in the soil. Due to the peculiar habits of the larvæ, they have often been mistaken for the maggots of the true fruit flies of the family *Trypetidæ* and have been the occasion of great alarm.

Nature of Work.—The maggots work within the roots and fruits, usually when they are in the process of decay. It is not a pest of healthy tissues.

Distribution.—This fly occurs quite commonly throughout the State, but is more abundant in the warmer sections of the central and southern parts.

Food Plants.—This species caused considerable alarm some years ago, when it was found working upon muskmelons in Tulare County, but investigation showed that only the injured or decayed melons were attacked. No less anxiety was aroused in the summer of 1912, when maggots were found in apparently sound oranges in Los Angeles County, but they also proved to be of this harmless fly. According to Professor J. M. Aldrich, the maggots are known to attack onions, osage orange, cotton bolls, sumach fruits, berries of horse nettle (*Solanum carolinense*) and decaying apples. The roots of loco weed (*Astragalus mollissimus*), sugar beets and cabbage are also hosts.

Control.—Remedies are not necessary for this fly, as it is not a pest.

TRYPETIDÆ (Family)

FRUIT FLIES

The members of this family are numerous, quite small, and usually have prettily marked wings. The abdomen has four or five segments. The male genitalia are little exposed, while the ovipositors of the females are more or less projecting. The maggots live in fruit, vegetables and stems of the plants, entirely ruining the hosts in the former cases and producing galls in the latter. This family is known the world over because of the many serious fruit flies which belong to it and which are so serious to fruits. The Mediterranean fruit fly, Mexican orange maggot, melon maggot, olive fruit fly, railroad worm of the apple, cherry fruit fly, and the currant or gooseberry fruit fly are among the members of the family.

²⁴⁵This fly was listed under the common name of cantaloupe fly in first edition.

THE PARSNIP LEAF-MINER

Acidia fratria (Læw)*(Trypeta fratria Læw)*

Description.—The flies are very small, being no more than $\frac{3}{16}$ inch long with a wing expanse of $\frac{7}{16}$ inch. The general color is pale yellow. The abdomen is pale green, the eyes red, the wings clouded with yellow and the ovipositor black and yellow. The maggots are yellowish-white, often appearing greenish. When fully matured they are $\frac{3}{8}$ inch long and one fifth as wide. The puparia are regularly oval with lower side slightly flattened. They are first pale green, becoming straw-colored with age, distinctly eleven segmented, $\frac{1}{6}$ inch long and half as wide.

Life History.—The life history is imperfectly known. In all probability the eggs are laid upon the leaves, near the edges, and upon hatching the larvæ enter the tissues just under the upper epidermis. Numerous mines are made before the maggots are fully matured. Pupation takes place within the mines, the adults issuing in about two weeks.

Nature of Work.—The work consists in the making of numerous irregular mines just under the epidermis of the leaves by the larvæ. These mines may be so thick as to completely cover the leaves and are usually made only near the bottom of the plants or in shady places elsewhere. Old seed-bearing plants are apparently preferred.

Distribution.—The parsnip leaf-miner occurs in this State,²⁴⁶ but the distribution is not well known.

Food Plants.—The leaves of the cultivated parsnips are ordinarily infested. According to Professor J. M. Aldrich, it was reared from the leaves of giant wild parsnip, *Heracleum lantanum*, in eastern Washington by C. V. Piper.

Control.—A repellent such as carbolic acid emulsion, applied to prevent egg-laying in the spring, may prove of practical value. Poison sprays have also been recommended to kill the larvæ as they enter the leaf. Trap crops of seed-plants are very useful and should be burned when they become thoroughly infested.

THE CURRANT OR GOOSEBERRY FRUIT-FLY²⁴⁷*Epochra canadensis* (Læw)*(Trypeta canadensis Læw)*

(Figs. 340, 341)

Description.—The flies are about as large as house flies, orange yellow in color, with the two wings beautifully clouded with yellowish markings. The eyes are green. The adults are very active and restless. The eggs are oblong, shiny white, with a short pedicle at one end and slightly over 1.25 inch in length. The maggots are white with black

²⁴⁶Woodworth, Cal. Insects, p. 135, 1913.

Bul. 82 pt. II, Bur. Ent. U. S. Dept. Agric., pp. 11-12, 1909.

²⁴⁷Saunders, W., Ins. Pests, Farm, Garden, Orchard, p. 352, 1883.

Gillette, C. P., Bul. No. 19, Colo. Agrcl. Exp. Sta., p. 18, 1892.

Harvey, F. L., Ann. Rept. State Coll. Me., pt. 2, p. 111, 1895; Bul. No. 35, Me.

Agrcl. Exp. Sta., 1897; 13th Ann. Rept. Me. Agrcl. Exp. Sta., p. 25, 1897.

Piper, C. V., and Doane, R. W., Bul. No. 36, Wash. Agrcl. Exp. Sta., 1898.

Johannsen, O. A., Bul. No. 177, Me. Agrcl. Exp. Sta., p. 36, 1910.

Paine, J. H., Psyche, XIX, No. 5, pp. 139-144, 1912.

mouth hooks. They are about $\frac{1}{4}$ inch long. The puparia are regularly oblong, light straw-colored or dark brown and about $\frac{3}{16}$ inch long.

Life History.—The winter is passed in the pupal stage in the soil and the adults begin to emerge about the middle of May. The eggs are laid within the berries, the females using their sharp ovipositors to deposit them just beneath the skin. About two hundred eggs are laid, usually but one in each berry. Egg-laying begins in May and continues in June. The eggs hatch in from one to two weeks and the maggots at once begin to work in the berries, usually among the seeds. By the middle of the summer, or by early fall, the maggots are full-grown and then leave the berries to enter the soil, where pupation takes place within two or three inches beneath the surface. Here the winter is also passed,



Fig. 340.—Gooseberries showing the work of the currant or gooseberry fruit-fly, *Epochra canadensis* (Lew.). Slightly enlarged. Specimens received from O. E. Bremner, Santa Rosa. (Original)

as previously indicated. The pupal stage is very long, requiring from six to ten months. There is but one brood a year.

Nature of Work.—The egg punctures made in the skin of the berries by the female flies cause at first a slight dimple or depression, but as the maggots develop the spot sinks and becomes brown or reddish and very noticeable. (Fig. 340.) The work of the maggots within the berries causes them to drop or ripen prematurely and destroys all affected. The presence of the maggots in any of the fruit is such as to make the entire crop unsafe for successful marketing.

Distribution.—The presence of this fly appears to be limited to the central and northern parts of the State. It has been reported as especially injurious in the region of San Francisco Bay and in the upper Sacramento Valley.

Food.—The fruit of currants and gooseberries appears to be the only food of this pest.

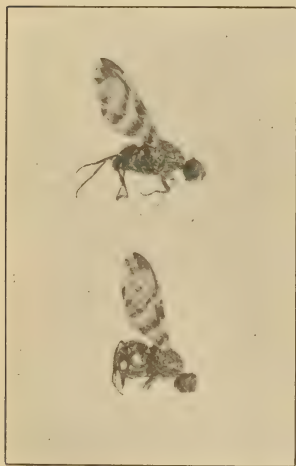


Fig. 341.—Adult females of the currant or gooseberry fruit-fly, *Epochra canadensis* (Lew.). Enlarged nearly three times. (Original)

Control.—The control of any fruit-infesting maggot is very difficult and at best may only be a slight help in preventing the entire loss of crops. The gathering and destruction of all green berries before they begin to fall will remove practically all of the next year's brood, but this is a very difficult matter, even in a small patch, and beyond question in large acreages. Thorough cultivation during the winter will expose many of the hibernating puparia and cause their destruction, especially by allowing poultry to pick these up after each cultivation. Covering each bush with fine netting, tying it securely around the base, to prevent the entrance of the flies as they emerge from the ground, is to be recommended for the small garden.

THE POMACE FLY

Drosophila melanogaster Meigen²⁴⁸ (Family Drosophilidae)
(*Drosophila ampelophila* Læw)

(Fig. 342)

Description.—The adults are small, light brown or orange-colored flies with bright red eyes. The tips of the abdomens of the males are dark. The average length is about $\frac{3}{32}$ inch. The eggs are oblong, exceedingly small, and have two long projections or wings. The maggots are white and $\frac{1}{4}$ inch long. The pupæ are yellow or brown with light markings near the anterior end, which bear two long horn-like breathing tubes. This species can always be distinguished by the comb of black spines on the upper side, near the tip of the front tarsus of the male.

Life History.—The eggs are deposited in suitable feeding places for maggots on decaying vegetables, canned, pickled or soured fruit. The maggots work upon the above fruits until they are ready to pupate. This takes place among the refuse, the adults appearing within a few days. The entire life history seldom covers more than fifteen or twenty days.

Distribution.—This species is exceedingly common throughout the entire State.

Food.—Canned, pickled and sour fruits, and decaying vegetable matter form the principal food. The author has reared the adults from soured and decaying bananas, pickled figs and decaying radishes.

²⁴⁸Johnson, C. W., Psyche, XX, pp. 202-203, 1913.

There are three other common species in California as follows: *Drosophila busckii* Coq., which greatly resembles the pomace fly, but is much smaller and has fine, dark, transverse lines on the abdomen. It has been reared from decaying squashes, bananas and potatoes. *Drosophila repleta* Woll. is much larger than either of the two former, being slightly more than $\frac{1}{4}$ inch long and rather robust. The body is also considerably darker, the abdomen being striped above with heavy, black, transverse lines. It is an imported species and breeds in decaying bananas and other fruits. The author has not seen specimens of *Drosophila apicata* Thom., the larvæ of which mine the leaves of cabbage.

Control.—Though these flies are of little or no economic importance, a description is included here to clear up the many misapprehensions that the maggots might be those of the Mediterranean fruit fly or some other imported fruit fly.



Fig. 342.—The pomace fly, *Ampelophila melanogaster* Meigen. Adults at top and maggots and puparia at bottom. Enlarged four times. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

However, the insects often trouble pickles and preserved fruits, but it is only necessary to keep these securely covered to prevent the entrance of the flies.

AGROMYZIDÆ (Family)

The members of this family are small or minute flies, which are not easily separated from the closely allied families. The front of the head is rather broad; the antennæ, short with the arista, when present, bare or only pubescent. The wings are relatively broad. The habits of the larvæ are varied; a large number are leaf-miners; some are predaceous upon aphids, scales and other small soft-bodied insects, while still others make galls in which they live.

THE SERPENTINE LEAF-MINER²⁴⁹

Agromyza pusilla Meigen²⁵⁰

(Fig. 343)

Description.—The adults are very small, varying from 1-25 to $\frac{1}{16}$ inch in length. The color is variable, but black predominates.



Practically all of the head (excepting the eyes), parts of the thorax, legs and abdomen, the scutellum and halteres are light yellow. The wings are transparent. The eggs are white, oval, about $\frac{1}{100}$ inch long and are deposited just under the epidermis on the upper surface of the leaves. The maggots are yellow with black mouth-parts, largest near the anterior end and truncate at the posterior end. When full-grown they are about $\frac{1}{8}$ inch long. The puparia are oval, strongly segmented, shiny-brown and nearly $\frac{1}{12}$ inch long. The spiracles on each end are prominent.

Life History.—Egg-laying begins in the spring of the year (May) by the females, which appear at that time. The eggs are thrust singly into the leaf tissues until just beneath the upper epidermis from the under surface, by the ovipositor of the females. They hatch within from three to eight days and the maggots at once begin to make their mines just beneath the upper epidermis of the leaves. The mines at first are very slender, but gradually become wider as the maggots mature.

The surface of the leaves may be traversed with their irregular mines or the entire epidermis may be completely separated from the remainder of the leaf. Maturity is

²⁴⁹Webster, F. M., and Parks, T. H., Jr., Agrcl. Resch. U. S. Dept. Agric., Vol. I, No. 1, 1913. Most of the above information is taken from this paper.

²⁵⁰Determined by Prof. J. M. Aldrich.

reached in from three to twelve days. Pupation takes place in an enlargement at the end of the mine, usually near the under surface of the leaves, beneath litter on the surface or just below the surface of the ground. In California pupation takes place almost entirely within the mines in the leaves. During the summer the pupal stage requires from one to two weeks, with an average of about ten days. The adults emerge by cutting a slit through the epidermis of the leaf. The life cycle during the summer averages about twenty-three days, and from one to one and one half months in late autumn. There are from three to five generations a year.

Nature of Work.—The small egg-punctures may be observed on the under surface of the leaves. From these the small mines are made just beneath the upper epidermis. The mines are easily traced by the discolored tissues just above them. They may be short or long and winding enough to completely sever the epidermis and cause it to appear white and dead. The plants may thus be greatly weakened and the whole field may appear exceedingly unhealthy. Usually, however, the damage is confined to single plants or to small areas.

Distribution.—Webster and Parks²⁵¹ report the species from San Francisco, Los Angeles and Imperial counties. On May 5, 1914, Mr. Leroy Childs collected the larvæ mines at Redding, Shasta County. From these adults were subsequently reared. The insect probably has a wide range over the State.

Food Plants.—In California the serpentine miner has been reared from alfalfa in Imperial and Shasta counties, from cabbage and sugar beets in Los Angeles County and spinach in San Francisco County.²⁵¹ Webster and Parks²⁵² also report the following other hosts from the United States: garden beet, red clover, sweet clover, white clover, cotton, cowpea, smooth rock-cress, fenugreek, common malva, hedge mustard, nasturtium, sweet pea, pepper, plantain, potato, radish and rape. The following additional plants are also reported from Europe by the same authors: bellflower, zigzag clover, garden daisy, dandelion, European elder, hedge nettle, hemp nettle, henbane, rest-harrow, bladder senna, cypress spurge and sow thistle.

Control.—Clean culture and deep fall plowing have been recommended for annual crops and frequent cuttings for such hay crops as alfalfa and clover. For garden crops use the remedies recommended for the chrysanthemum leaf-miner.

THE ASPARAGUS MINER

Agromyza simplex Loew

(Fig. 344)

Description.—The flies have a wing expanse of about $\frac{1}{8}$ inch and are metallic-black in color. The maggots are $\frac{1}{2}$ inch long and white. The puparia are $\frac{1}{2}$ inch long and red or brownish.

Life History.—The first adults appear early in the spring and begin egg-laying. The larvæ mine beneath the epidermis of the stalks near the bases and may penetrate eight inches underground. The injury

²⁵¹Jr. Agrcl. Resch. U. S. Dept. Agric., Vol. I, No. 1, pp. 62-63, 1913.

²⁵²Jr. Agrcl. Resch. U. S. Dept. Agric., Vol. I, No. 1, pp. 63-64, 1913.

is often so severe as to completely girdle the stems and thus much damage may result. The puparia are formed in the burrows, especially on the roots and bases of the stalks. There are at least two generations each year.

Nature of Work.—The maggots work just beneath the epidermis of the stalks and often completely girdle the stems, thereby killing the tops. The dead and dying stalks usually indicate the presence of this pest.

Distribution.—This fly has been reported by Mr. I. J. Condit at Antioch and Oakley, in Contra Costa County. It is probably partially distributed in the central part of the State.

Food Plants.—This pest works only upon asparagus plants.



Fig. 344.—The asparagus miner, *Agromyza simplex* Loew. Adult flies at the left, greatly enlarged. Immature forms at the right as follows: *a*, larva or maggot; *b*, thoracic spiracles and *c*, anal spiracles of the larva; *d*, side view and *e*, dorsal view of the puparium; *f*, section of asparagus stalk, showing injury caused by the maggots and sections removed to show location of the puparia. All except *f* are greatly enlarged. (After Chittenden, U. S. Dept. Agric.)

Control.—The control of the fly is somewhat difficult and consists in the use of trap crops early in the spring, which should be removed, roots and all, and burned in June. Other traps should be allowed to grow up immediately and similarly destroyed in the fall.

Cutting out all infested stalks as often as they appear is also advisable.

D. E. Fink²⁵³ recommends the following spray to kill the larvæ in the infested stalks:

"Black leaf 40"-----	1 gallon
Soap -----	4 pounds
Water -----	500 gallons

THE WISTARIA STEM GALL-FLY²⁵⁴

Agromyza websteri Malloch

(Fig. 345)

Description.—The flies are very small, not exceeding $\frac{1}{8}$ inch in length. They are black and hairy with rather large reddish-brown eyes. The maggots are white, $\frac{1}{5}$ inch long and larger at one end. The

²⁵³Bul. 331, Cornell Univ. Agrcl. Exp. Sta., p. 419, 1913.

²⁵⁴Regarding the wistaria stem gall-fly, Prof. J. M. Aldrich makes the following comment: "This species is made distinct by Malloch in his paper on the family under the name *Agromyza websteri* Malloch. It is closely allied to *A. schineri* and, as but little material is available, I am not yet quite satisfied that they are not the same. The undoubted *A. schineri* (Giraud) makes similar galls, but on poplar. I had it from Colorado last year."

puparia are regularly oval; dark brown to almost black, about $\frac{1}{8}$ inch in length and one third as wide.

Life History.—It is believed that the eggs are laid in the early spring, by the adults, near the buds of the food plants, for here the maggots usually enter and form an enlargement or gall, where feeding and pupation take place.

Nature of Work.—The presence of the maggots is indicated by the small galls, or swellings, at the bases of the buds along the stems of the pink-flowering wistaria.

Distribution.—Undoubtedly this fly is quite widely distributed, but it is reported only from San Diego County.

Food Plants.—The fly appears to attack only the pink flowering varieties of wistaria.

Control.—Cutting out and burning the infested branches and avoiding the planting of the pink flowering varieties are the best methods of controlling or avoiding the attacks of this fly.

THE DIPTEROUS PARASITE OF THE COTTONY CUSHION SCALE

Cryptochatum iceryæ (Williston)²⁵⁵
(*Lestophonus iceryæ* Williston)

Description.—The adults of this very beneficial insect are exceedingly small two-winged flies, about $\frac{1}{16}$ inch long. The head and thorax are metallic-blue and the abdomen bright iridescent-green. The antennæ are black; legs, black or dark brown with feet light; wings, grayish, hyaline with dark brown veins.

Life History.—The life history has never been fully studied and there are many conflicting opinions regarding it. Mr. E. J. Vosler, Assistant Superintendent of the State Insectary, reared flies from the bodies of the scales.

Distribution.—This fly is practically confined to the citrus growing sections of southern California and is most abundant in Los Angeles, Orange and San Diego counties. Professor R. W. Doane has reared specimens from the cottony cushion scale at Stanford University, where it is fairly common.

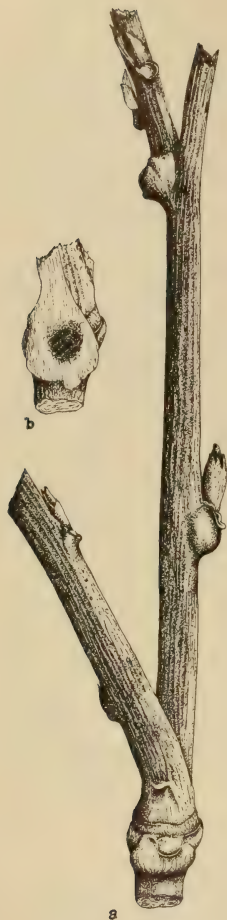


Fig. 345.—Wistaria stems, showing galls produced by the wistaria stem gall-fly, *Agromyza websteri* Malloch. Enlarged. (After Amundsen, Mo. Bul. Cal. Hort. Com.)

²⁵⁵According to Frederick Knab, the species preying upon the cottony cushion or fluted scale in California is probably *Cryptochatum monophlebi* Skuse and not *Cryptochatum iceryæ* (Will.) as has been previously reported. (Insector Insectiæ Menstruus, II, No. 3, pp. 33-35, 1914)

Host.—The cottony cushion scale (*Icerya purchasi* Mask.) is the normal host of this insect, and while it is not as consistent and reliable in its work upon the scale as are the ladybird beetles (*Novius cardinalis* and *N. kabelei*), yet its work is often phenomenal. During the summer of 1912 Mr. A. S. Hoyt, Deputy State Quarantine Officer, reared quantities of the flies in Los Angeles County.

THE WILD PARSNIP LEAF-MINER

Phytomyza albiceps Meigen

(Fig. 346)

Description.—The flies are exceedingly small, black or metallic-blue, with the front and cheeks, bases of the wings, bands around the last segment of the abdomen, knees of the femora and the tibiae yellow. The length is about $\frac{3}{8}$ inch. The puparia are black with two noticeable breathing tubes at one end.

Life History.—The life history of this species greatly resembles that of the chrysanthemum leaf-miner, except that the pupal stage is not passed within the mines, but in the soil.

Nature of Work.—The work greatly resembles that of the chrysanthemum leaf-miner.

Distribution.—This fly is generally distributed throughout the State. It was taken in large numbers in the San Francisco Bay region in June, 1914, by the author.

Food Plants.—The leaves of the giant wild parsnip are commonly attacked in this State.

Natural Enemy.—A majority of the puparia are parasitized by a small black hymenopterous insect (*Diadlinus begini* Ashm.).



Fig. 346.—Pupæ and adults of the wild parsnip leaf-miner, *Phytomyza albiceps* Meigen. The three specimens of *Diadlinus begini* Ashm. were reared from the pupæ. Enlarged twice. (Original)

THE CHRYSANTHEMUM LEAF-MINER

Phytomyza chrysanthemi Kowarz

[*Napomyza chrysanthemi* (Kowarz)]

(Fig. 347)

Description.—The flies are very small, averaging about 2-25 inch in length. The face is yellow; antennæ, black; thorax and scutellum, gray with a pale yellow stripe in front of the base of each wing; the abdomen, black with ventral sides pale yellow, and the legs, black with yellow markings. The maggots are light and very small. The puparia are dark brown and located within the mines in the leaves.

Life History.—The life history of this fly is not fully known, but probably greatly resembles that of the serpentine leaf-miner in the more important aspects.

Nature of Work.—Figure 347 shows the work of this fly, which consists in the making of large numbers of mines just under the upper epidermis of the leaves. The infested plants become sickly and greatly disfigured by the attacks.

Distribution.—The chrysanthemum leaf-miner has been quite destructive to plants at Oakland during the past year (1914). It was



Fig. 347.—The chrysanthemum leaf-miner, *Phytomyza chrysanthemi* Kowarz. Flies and mines on cineraria leaf. Enlarged three times. Specimens received from F. Seulberger, Oakland. (Original)

first taken and forwarded to the writer by Mr. Fred Seulberger, county horticultural commissioner of Alameda County.

Food Plants.—Many of the *Composita*, including chrysanthemum, cineraria, *Eupatorium*, marguerite and Shasta daisy are attacked.

Control.—Prof. J. G. Sanders found that the eggs as well as the larvæ and newly formed pupæ within the mines could be killed with an application of one part of "black leaf 40" to 400 parts of water, and that the pupæ of all ages could be killed by increasing the proportions 1 to 200.²⁵⁶

²⁵⁶Tr. Ec. Ent., V, p. 472, 1912.

HYMENOPTERA (Order)

MEMBRANOUS-WINGED INSECTS

BEES, WASPS, GALL-FLIES, SAWFLIES, HORNTAILS, ANTS.

This is the fourth largest order of insects, comprising not only some of the most beneficial forms like the honey bees and parasitic insects, but some very injurious forms like the sawflies and Argentine ant. The transformations are complete, the larva being maggot or grub-like and the pupa quiescent. The adults usually have four well developed membranous wings and are powerful fliers, but a great many members have no wings at all. The jaws are well developed for biting, but the other mouth parts may be modified for sucking and lapping. There is a very extraordinary phenomenon of the repression of sex maturity and the development of a sting in the females of certain families, while the phenomena of virgin-birth and the formation of galls are no less wonderful.

SIRICOIDEA (Superfamily)

HORNTAILS

The horntails somewhat resemble the sawflies in general appearance, coloration and the two-segmented trochanters. The ovipositor, however, is in the form of a long spear or horn and not saw-like, and there is but one apical spur on each front tibia instead of two. The larvæ usually feed within the small twigs or in solid wood. The tip of the abdomen is curved backwards and ends in a small pointed tubercle.

THE WESTERN GRASS-STEM SAWFLY

Cephus occidentalis Riley and Marlatt (Family Cephidæ)

(Fig. 348)

Description. — The adults are shining black, spotted and banded with yellow and about $\frac{1}{2}$ inch long. The larvæ are yellowish-white with head, pronotum, palpi rings, tips of paired cerci and setæ of the last abdominal segment, pale yellow. The mandibles are dark. They are larger near the head, tapering towards the tip, which ends in a brown tubercle. When fully-matured they are $\frac{3}{4}$ inch long and one eighth as wide. Though one of the horntails, this insect is commonly known as a sawfly.

Life History. — The eggs are laid singly upon the stems of the food plants in May and June. Immediately upon hatching, the larvæ bore down the stems and reach the ground in the fall. Within the stem near the surface of the ground they enlarge the burrow and remain there, quite active during the winter. At the enlargements the stems are greatly weakened and break off. Within them a silken cocoon is spun and pupation takes place in the spring (April and May) and the adults issue in May and June, when egg-laying begins. There is but a single brood a year.

Nature of Work. — The stems of the infested plants become discolored and break off at the cell made in the fall, near the surface of the ground. Much damage may be done.

Distribution.—This insect is a native of California and was first reported from the Santa Cruz Mountains, Santa Cruz and Santa Clara counties, in 1890, by Albert Koebele.²⁵⁷

Food Plants.—Brome grass (*Bromus* sp.), quack grass, rye, wild rye (*Elymus*), timothy, wheat and wheat grass (*Agropyron*) are attacked.

Control.—As the larvæ hibernate in the standing grass or stubble, it is well to resort to burning or plowing under the stubble in the fall or winter and to remove all host plants in uncultivated areas. Mowing in the spring, as soon as eggs are hatched (June and July), will kill the

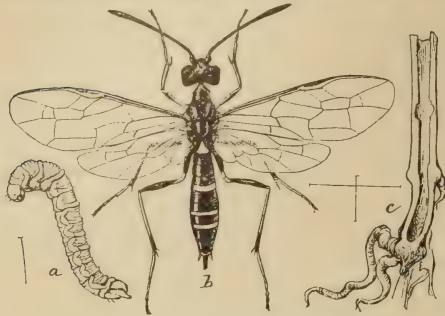


Fig. 348.—The Western grass-stem sawfly, *Cephus occidentalis* Riley and Marlatt. *a*, larva; *b*, female; *c*, grass stem showing work of the larva. (After Marlatt, U. S. Dept. Agric.)

young and reduce infestation for the following year. If wild grasses in the neighborhood are infested the crop rotation plan is claimed to be the most feasible. In all probability the work of this insect will never become serious enough to warrant any such expensive control measures.

²⁵⁷Insect Life, IV, p. 178, 1891.

THE RASPBERRY HORNTAIL

Hartigia cressoni (Kirby) (Family Sireiidae)(*Hartigia abdominalis* Cresson)

(Figs. 349-351)

Description.—The adults are slender wasp-like insects, little more than $\frac{1}{2}$ inch long and very active fliers. The females are yellow with dark markings, while in the males black predominates, with very little yellow. The eggs are pearly-white and oblong with a curved point at one end. The full-grown larvæ are white with dark heads and tip-

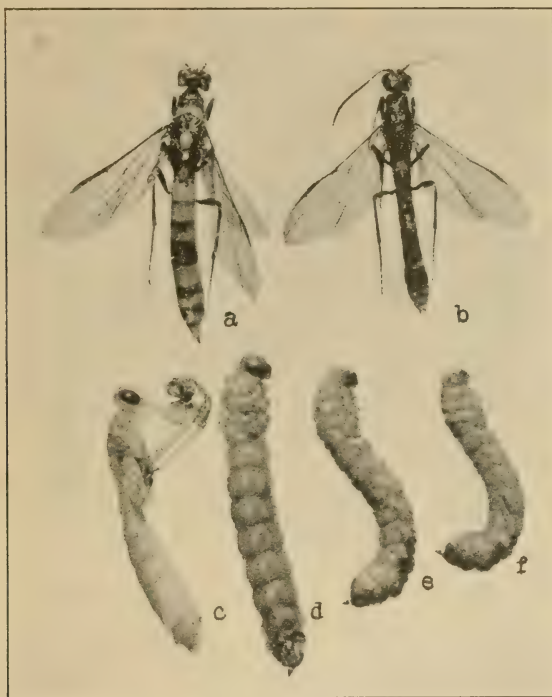


Fig. 349.—The raspberry horntail, *Hartigia cressoni* (Kirby), a, adult female; b, adult male; c, pupa; d, first-stage pupa; e, and f, larvæ. Enlarged two and one half times. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

ends are nearly 1 inch long. They are almost the shape of the letter "S" and have a very noticeable point at the tail end. The pupæ vary from the color and shape of the larvæ to those of the adults.

Life History.—The winter is passed within the canes of the host plants in the larval and pupal stages. The adults emerge in April

and after mating the females begin to insert their eggs in the tender tips of the young shoots. The eggs hatch in a short time into larvæ, which work up the shoots until the latter are killed, when they turn and go down the middle pith of the stems and transform in the late fall, winter or early spring into pupæ. There is one, or possibly two, broods each year.

Nature of Work.—The egg punctures near the tips of the young shoots soon turn brown or black and are easily located. The new burrow, in the form of a spiral originating at the egg-puncture, and the withered tip are sure evidences of the presence of the pest. In the canes the burrows are made by the larvæ down through the pith, nearly to or into the roots. The adults cut a circular hole through the side



Fig. 350.—Eggs of the raspberry horntail, *Hartigia cressoni* (Kirby). Outer epidermis of tender shoot skinned back to show the eggs *in situ*. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

of the canes to escape. The principal damage is to the young shoots, cutting off the main crop of blossoms and fruit. In some districts 50 to 90 per cent of the young shoots are thus killed at the tips. These send up secondary shoots, which bear fewer, smaller and later berries.

Distribution.—This horntail is widely distributed throughout the Sacramento and San Joaquin valleys and is especially destructive in the Sierra foothills.

Food Plants.—The native host of this insect is probably the wild rose. Raspberries suffer most from the attacks. Cultivated roses, blackberries and loganberries are also food plants.

Control.—Measures necessary to remove or destroy the eggs before the young larvæ hatch should be inaugurated. As the eggs are very

tender and their location plain, great numbers may be quickly destroyed by exerting a slight pressure over them with the thumb, which in no way injures the shoot. Cutting out infested canes is also recommended.

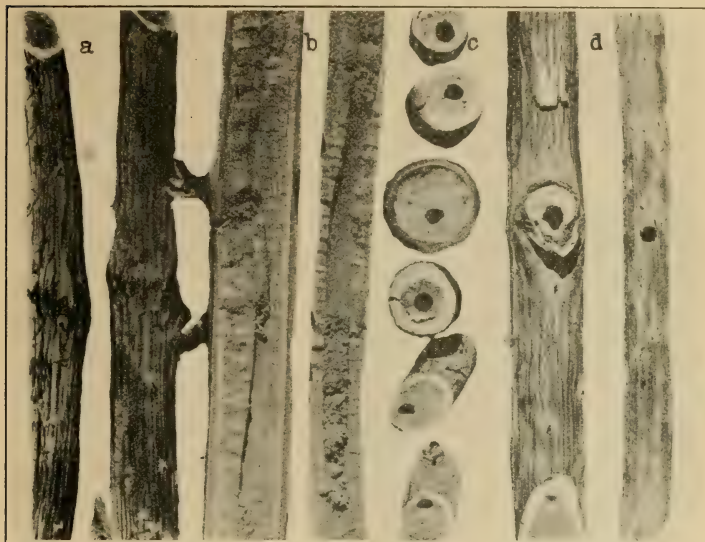


Fig. 351.—Old raspberry canes showing the work of the raspberry horntail. a, spirals made around the canes by the young larvæ; b, longitudinal sections of canes showing the larval burrows in the pith; c, cross-sections of canes showing burrows in pith; d, exit holes made by the adults. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

Natural Enemies.—During the summer of 1914 the State Insectary reared two parasites from the raspberry horntail—one a *Pimplidea* and the other a pteromalid.

TENTHREDINOIDEA (Superfamily)

SAWFLIES

The members of this superfamily have two-segmented trochanters; two apical spurs on the tibiae of the forelegs and the females have a pair of saw-like processes constituting the ovipositor with which the eggs are laid in the tissues of plants. The head and thorax are wide and the base of the abdomen is not constricted. The larvæ are entirely naked and greatly resemble caterpillars. They have besides the three pairs of thoracic legs from six to eight pairs of prolegs, while most caterpillars (except in the rare family *Megalopygidae*, which have seven pairs of prolegs) have from two to five pairs of prolegs. Some of the larvæ cover themselves with a slimy fluid and are known as slugs, the

pear slug being a familiar example. Most of the young feed upon foliage or in stems of plants, while a few make curious galls in which they live.

THE PEAR OR CHERRY SLUG

Caliroa cerasi (Linnaeus) (Family Selandriidae)

(*Eriocampoides limacina* Retzius)

(*Selandria cerasi* Peck)

(Figs. 352, 353)

Description.—The adult is a glossy, black, four-winged insect about $\frac{1}{2}$ inch in length. The larvæ are dark olive-green, slimy and from $\frac{3}{8}$ to nearly $\frac{1}{2}$ inch in length. Their work is very noticeable and consists in



Fig. 352. — Pear leaf showing hatched and unhatched eggs as well as the work of the larvæ of the pear or cherry slug, *Caliroa cerasi* (Linn.). Enlarged three times. (Original)

the removal of all of the upper green surface of the leaf, causing the injured areas to turn brown. Badly infested trees appear scorched as if by fire. The eggs are oval, slightly flattened on one side and deposited under the epidermis of the leaves, usually on the under sides, by the sharp ovipositor of the female.

Life History. — The eggs are deposited during the spring and summer (May, June and July) and hatch in about two weeks. The larvæ cut semi-circular holes in the upper surface of the leaves and begin to feed. They are first white and later become dark green, because of the slimy secretion. The entire green upper surface of the leaves is removed by the larvæ until only skeletons are left. The remaining under surface turns brown. When full-grown

the larvæ crawl an inch or so into the ground and spin thin cocoons in which to pupate. The first brood reaches the adult stage by the middle of the summer and gives rise to a second brood, the pupæ of which hibernate in the soil. The adults appear early in the following spring.

Nature of Work.—The slugs eat the green portion of the leaf from above and their work is well illustrated by Fig. 353. Trees which are badly infested appear brown, due to the foliage being thus killed.

Distribution.—It is generally distributed throughout the State.

Food Plants.—The cherry and pear are the preferred host plants, but buttonbush, hawthorn, Juneberry, mountain ash, plum and quince are also attacked.

Control.—This is one of the easiest pests to control. The larvæ readily succumb to the ordinary soap or emulsion sprays and may be effectually destroyed by blowing dust upon the infested leaves. A spray composed of 2 pounds lead arsenate to 50 gallons of water is also very efficient in controlling it.

Natural Enemies.—Without doubt the reason for this pest's not becoming more serious in California is due to the natural enemies which hold it in check. In this State these enemies have never been recorded, but in the Middle States the egg parasites, *Trichogramma minutum* Riley and *Closterocerus cinctipennis* Ash., are quite common.

There are probably also parasites working on the larvæ. This, however, has never been definitely ascertained. The spined soldier-bug, *Podisus maculiventris* Say, and the rapacious soldier-bug, *Sinea diadema* Fab., are active enemies of the larvæ and adults. The larvæ of the green lacewing also devour many of the young. Both of the last two insects occur in California. Hot weather also reduces the numbers.



Fig. 353.—Larvæ of the pear or cherry slug and their work on a pear leaf. Natural size. (Original)

THE CHERRY FRUIT SAWFLY²⁵⁸

Hoplocampa cookei (Clarke) (Family Doleridae)

(*Dolerus cookei* Clarke)

(*Hoplocampa californica* Rohwer)

(Figs. 354, 355)

Description.—The adults are mostly black, with light reddish-brown or yellowish legs and antennæ. A portion of the head is also reddish. The females are about 1.9 inch long and the males $\frac{1}{2}$ inch long. They have four well-developed wings and their general appearance is well shown in Fig. 355. The eggs are whitish, shiny, somewhat kidney shaped and about 1.50 inch long and 1.75 inch wide. The full-grown larvæ are yellowish-white, with the head, tip of abdomen and legs darker yellow and the eyes black. They have three pairs of well-developed legs near the head, six pairs of small prolegs behind these and one pair of prolegs at the posterior end of the body. The body is usually curved in the shape of a crescent and is distinctly segmented and wrinkled. At first the pupæ are the same color as the larvæ and gradually assume the color of the adult as maturity is reached.

Life History.—According to Foster²⁵⁸ the females appear in the spring, just about the time the Black Tartarian cherries are beginning

²⁵⁸Foster, S. W., Bul. No. 116, pt. III, Bur. Ent. U. S. Dept. Agric., 1913, Mo. Bul. Cal. Hort. Com. III, pp. 31-35, 1914.

to bloom. They deposit their eggs singly in the sepals of the flowers or in the upper portion of the calyx cup, always on the blossom buds, just before the petals open. The insertions are made by the sharp ovipositor and the eggs are well buried in the plant tissues. In the interior valleys egg-laying begins about the middle of March. Usually but one egg is deposited in a single flower, though this is by no means a fixed rule.

The eggs hatch in about four or five days, though the time may vary from three to six days. Soon after hatching, the young larvæ eat their way into the young cherries and work upon the tender kernels, where they feed from two to four days, or until the interior is devoured and the fruit withers. They then seek new cherries and repeat the process, each destroying a second and often a third before becoming full-grown. By the time the third cherry is reached the kernel is too hard to be eaten, so only portions of the meat around it are consumed, which often includes nearly or over half of the fruit. The entrance to the first cherry is exceedingly obscure, but the small, round holes are plainly visible in the second and work on the third is very conspicuous.



Fig. 354.—Cherries showing the work and larva of the cherry fruit sawfly, *Hoplocampa cooki* (Clarke). Natural size. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

It is not known if the above data hold true with regard to the insect's work on the prune, plum and other hosts, for the complete life history has not been studied in the localities where these fruits are attacked. The larvæ reach maturity in from twenty-two to twenty-six days and then leave the fruit to enter the ground, to a depth of from three to seven inches, for pupation. The pupæ remain in the ground over winter and emerge as adults in March, when egg-laying begins, as soon as the well-formed blossom buds appear. There is but a single generation a year.

Nature of Work. — Evidences of the work do not show until the young cherries begin to turn yellow and drop. Examination discloses the small, round holes and the empty interiors. Later fruits show much of the fleshy portions around the seeds removed. In not a few cases, from 50 per cent to nearly 90 per cent of the fruit is injured and drops prematurely because of the attacks. Other fruits are also injured in a similar manner.

Distribution. — The insect is generally distributed throughout the San Francisco Bay region, the Sacramento Valley and the Sierra foothills, east of the Sacramento Valley. It also extends into Oregon, where considerable damage is done, in the Rogue River Valley.

Food Plants.—The principal food in California is the fruit of the cherry. Professor W. T. Clarke also reports finding eggs in the calyces of plum trees.²⁵⁹ In Oregon, P. J. O'Gara has found the insect more destructive to prunes and plums than to cherries. He also records as hosts apricots, sweet and sour cherries and peaches.

Control.—Two or three applications of arsenate of lead, 4 to 5 pounds to 100 gallons of water, usually suffice to control the pest. The first spraying should be made shortly before the blossoms open, and the second about ten days later, when the petals have practically all fallen. If necessary, a third application should be made in about



Fig. 355.—The cherry fruit sawfly, *Hoplocampa cookei* (Clarke). *a*, egg; *b*, position of egg in the blossom; *c*, larva; *d*, adult female; *e*, saw of the female's ovipositor; *f*, serrations on saw; *g*, sheath of the saw; *h*, head of adult, front view; *i*, infested cherries showing larva inside and exit and entrance holes. *a*, *c*, *d*, *e*, *f*, *g* and *h*, greatly enlarged; *b* and *i*, slightly enlarged. (After Foster, U. S. Dept. Agric.)

another week's time. The first spraying is to kill the first hatched larvæ as they enter the very small fruits, and the second and third are to prevent them from entering other fruits.

Several thorough cultivations, just after picking time or during the fall, has been suggested as a means of destroying many of the pupæ in the soil.

Natural Enemies.—Two undetermined internal hymenopterous parasites were reared from this insect by Mr. Foster. Perhaps the parasites are responsible for the slow spread and the spasmodic work at intervals of several years.

²⁵⁹Can. Ent. XXXVIII, p. 351, 1906.

THE CALIFORNIA PEAR SAWFLY

Gymnonychia californicus Marlatt²⁶⁰ (Family Nematidae)

(Figs. 356, 357)

Description.—The adult females are short, rather robust, shining black with yellow markings on the prothorax. The antennæ are black and are nearly or as long as the head and prothorax, with the third joint longest. The length averages about $\frac{1}{2}$ inch. The larvæ are light green, have twenty legs and are nearly $\frac{1}{2}$ inch long when full-grown.

According to Matthew Cooke, the eggs are deposited under the epidermis of the leaves and hatch in ten days.²⁶¹

Life History.²⁶²—The larvæ appear in April and May and begin to feed upon the leaves, continuing to eat holes in the surface or on the margins until full-grown, which requires about twenty-four days. They then fall to the ground and construct small brown cocoons in the soil around the base of the trees, where they hibernate. The adults emerge the following March. There appears to be but a single brood a year.

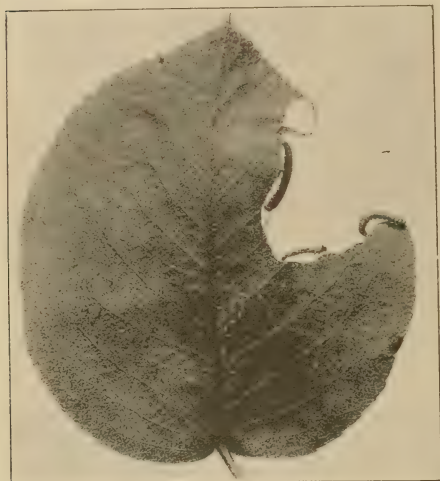


Fig. 356. The California pear sawfly, *Gymnonychia californicus* Marlatt. Larvæ and their work on a pear leaf. Natural size. (Original)

Nature of Work.—The work of the larvæ is very characteristic and consists in eating nearly circular holes in the leaves and along the margins; the larvæ in so doing assume the attitude as shown in Fig. 356. Considerable damage is done to the foliage in a few sections.

Distribution.—The California pear sawfly does not have as wide a distribution as does the pear slug, but it is nevertheless quite common throughout the central and northern parts of the State, having been taken in the Santa Clara Valley, the San Francisco Bay region and the Sacramento Valley. It was first reported as the pear-leaf caterpillar (*Nematus* sp.) by Matthew Cooke as early as 1881-82, who observed it in the Sacramento Valley.²⁶¹

Food Plant.—The pear is the only recorded food plant.

²⁶⁰Marlatt, C. L., Tech. Ser. No. 3, Bur. Ent. U. S. Dept. Agric., pp. 122-123, 1896.

²⁶¹Inj. Ins. of Orchard, Vineyard, etc., pp. 120-121, 1881-1883.

²⁶²The writer is indebted to W. M. Davidson for looking over this description. Mr. Davidson has made careful observations on this insect for several years and is undoubtedly more familiar with its life habits than any one else.

Control.—The application of arsenical sprays when the young begin to appear is the best remedy. The second codlin-moth spraying is usually sufficient to control this pest also.

PARASITIC HYMENOPTERA

Of the beneficial insects, by far the most effective are the hymenopterous parasites belonging to the superfamilies *Ichneumonoidea*, *Cynipoidea*, *Chalcidoidea* and *Proctotrypoidea*. Not all of the members of these superfamilies are beneficial. Some like the clover seed chalcis and the wheat joint-worm are injurious and many prey upon predaceous and parasitic insects. Not all the true parasites belong to these four superfamilies, for, as we have seen, many dipterous insects are very efficient parasites. In all the superfamilies, except the *Ichneumonoidea*, many of which are quite large, the members are usually exceedingly small, a hand lens or microscope being necessary for their study.



Fig. 357.—Adult female of the California pear sawfly, *Gynanocichus californicus* Marlatt. Enlarged six times. (Redrawn after Marlatt)

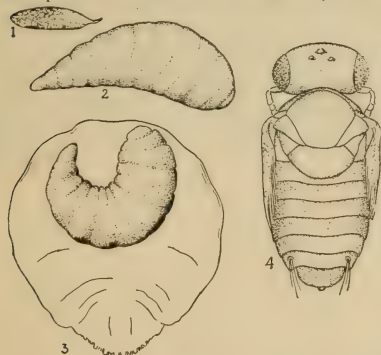


Fig. 358.—Various stages of the purple scale parasite, *Aspidiotiphagus citrinus* Craw. 1, egg; 2, larva; 3, larva inside the body of the scale; 4, nearly mature insect. Greatly enlarged. (After Quayle, Cal. Agrcl. Exp. Sta.)

within the host, attached or not attached to it.

There are great variations in the time of development, but one generation a year in some and many in others. The adults are usually four-winged insects with quick power of flight and great activity. Many of the smaller species have the ability to jump like fleas.

The work of all true parasites is rather spasmodic because of the very nature of their existence. Naturally, with the decrease in the numbers

members are usually exceedingly small, a hand lens or microscope being necessary for their study.

The females usually lay their eggs within, beneath or attached to the outer surface of the host or within the egg, by means of an ovipositor specialized for such purposes. Upon hatching, the young legless larvæ begin feeding upon the body or juices of the host or egg, the vital tissues of the former being reserved until the larvæ are nearly ready to pupate.

The entire larval period is passed within or upon the host. The pupal stage may be passed

of the hosts, the parasites die from lack of food and may be so reduced in numbers that they are not able to check the rapidly increasing numbers of the hosts and a serious infestation of injurious insects may

result. On the other hand, many cases are on record where serious outbreaks of insect pests have been brought under control in a marvelous way by these parasites, and in these cases they should be given credit for the great good accomplished.

Unfavorable weather conditions and the work of secondary parasites are also often responsible for the poor showing of these beneficial friends.

Not all of the insects belonging to the above superfamilies are strictly parasitic upon other animals. Some have become feeders of plant tissues and may be classed as injurious. In this latter group may be placed the clover seed chalcis and

Fig. 359.—Soft brown scale, showing exit holes of the parasite, *Microterys flavus* (How.). Greatly enlarged. (After Quayle, Cal. Agrcl. Exp. Sta.)

the wheat joint-worm, already referred to. The blastophaga feeds in the figs, but is beneficial as a fertilizing agent, which is necessary in the raising of certain varieties of figs.



THE PARASITE OF THE BLACK CITRUS PLANT LOUSE

Charips xanthopsis (Ashmead) (Family Figitidae)*(Allotria xanthopsis* Ashmead)

(Fig. 360)

Description.—This small parasite belongs to a family closely allied to the gall makers. The adults are exceedingly small, being less than 1-10 inch long. The general color of the body is black, with legs, bases of the antennae and ovipositor light amber.

Life History.—The life history of this insect is not well known, but probably resembles that of *Aphidius testaceipes* Cresson.

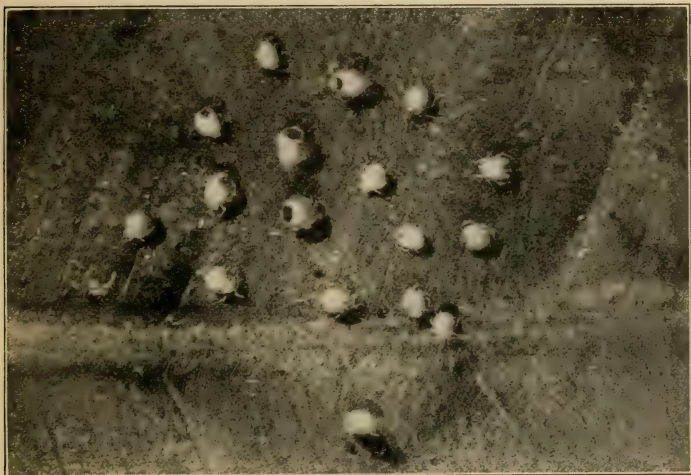


Fig. 360.—Mummied bodies of the black citrus plant louse, *Toxoptera aurantiae* Koch, showing exit holes of *Charips xanthopsis* (Ashm.). (Author's illustration, P. C. Jr. Ent.)

Distribution.—It is common in the southern part of the State, especially in Ventura County.

Host.—This parasite has been reared from the black citrus plant louse (*Toxoptera aurantiae* Koch), but it is probably a secondary parasite preying upon *Aphidius testaceipes* Cresson.

THE CODLIN-MOTH PARASITE²⁶³*Calliephialtes messor* Gravenhorst²⁶⁴ (Family Ichneumonidae)

(Figs. 361, 362)

Description.—The adult is black with reddish or yellowish legs and yellow markings on the body. The wings are brownish-hyaline with darker veins. The female is equipped with a long ovipositor, which is as long as the body. Exclusive of the ovipositor, she is nearly $\frac{1}{2}$ inch long. The male is about $\frac{3}{8}$ inch long. The eggs are white and rather long and slender, being largest near the middle and sharper at one end than the other. They average about 1-20 inch in length. The

²⁶³The real status and life history of this parasite has been recently worked out by Harry S. Smith and E. J. Vosler, who published their findings, much of which is included in this article, in The Monthly Bulletin of the Cal. Hort. Com., Vol. III, pp. 195-211, 1914.

²⁶⁴There is some doubt regarding the specific name, *messor*.

larva, when first hatched, is yellowish-white, has a prominent head and antennal protuberances and is legless. When full-grown, there is no sign of a head or antennæ, the larva appearing like a headless and legless, white or pinkish maggot, with very distinct body-segmentation. It averages about $\frac{1}{3}$ inch in length.

Life History.—The female of this parasite stings the larva of the codlin-moth in its cocoon and deposits a single egg in each. Each female may lay as many as one hundred eggs in this way. The larva passes through five stages before becoming full-grown, which

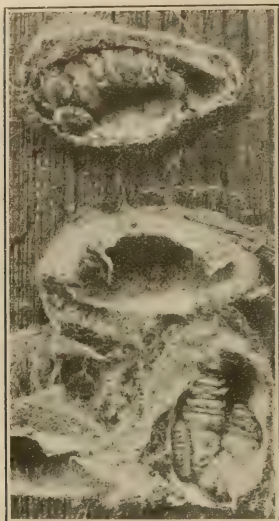


Fig. 361.—Larvæ of the codlin-moth parasite, *Calliephialtes messor* Grav., feeding upon the larvæ of the codlin-moth within the cocoons, portions of which have been removed to expose the insects. (After Smith and Vosler. Photo by author, Mo. Bul. Cal. Hort. Com.)



Fig. 362.—Adult female of the codlin-moth parasite, *Calliephialtes messor* Grav. Enlarged twice. (After Smith and Vosler. Drawing by Birdnekoff, Mo. Bul. Cal. Hort. Com.)

require from about twenty to thirty-five days. It then spins a thin yellowish-brown cocoon in the cocoon of the larva of the codlin-moth and in from thirteen to twenty-four days emerges as an adult. The adults may live as long as three months, but the average length is about two months. Under favorable conditions there are probably two or three broods a year.

Distribution.—This insect was imported from Spain by Mr. Geo. Compere. It has been reared for many years by the State Insectary and sent out in small lots to many apple-growing sections of the State. It has not become sufficiently established anywhere to be a factor in the control of the codlin-moth. For this reason the State Insectary has ceased to continue the breeding of the parasite for commercial purposes.

Host.—The larva of the codlin-moth is the common host,

PARASITE OF THE MELON APHIS

Aphidius testaceipes (Cresson) (Family Braconidae)
(Lysiphlebus testaceipes Cresson)

(Fig. 363)

Description.—The adults are exceedingly small to develop within the bodies of the plant lice, being but $\frac{1}{16}$ inch long. The body is very slender, dull or shiny black, with legs, antennæ and base of abdomen

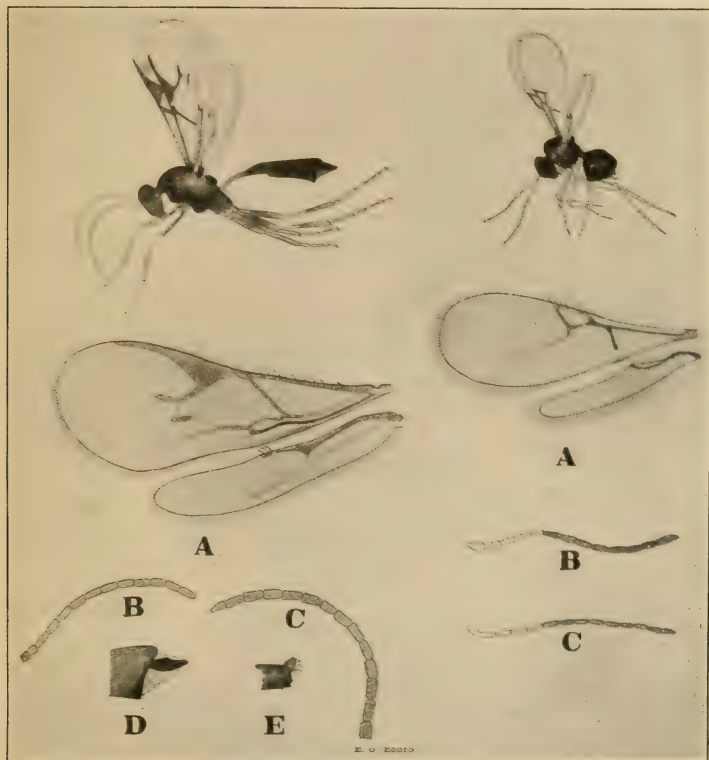


Fig. 363.—Parasites of plant lice. *Aphidius testaceipes* (Cr.) at the left and *Charips xanthopsis* (Ashm.) at the right. A, wings; B and C, antennæ; D, tip of female abdomen; E, tip of male abdomen. (Author's illustration, P. C. Jr. Ent.)

pale amber. The wings are hyaline and iridescent with pale amber stigmas.

Life History.—The females deposit their eggs within the living tissues, inside the bodies of the plant lice, by means of a long, sharp-

pointed ovipositor, which pierces the body walls of the lice. The outside wound heals over in a short time, leaving the egg tightly sealed within the body ready to hatch. As soon as the egg is hatched the small, legless larva begins to feed upon the tissues of the aphid and its development means the extinction of a louse. When it is fully developed and ready to leave the "mummied" louse, it cuts a circular hole in the top of the body and escapes an adult winged insect, ready to produce more eggs and thereby to destroy more lice. The life-cycle varies according to the time of year. In the colder months it covers from about ninety to one hundred days, while during the summer months it covers from eight to fifteen days. It often does very good work.

The so-called "mummied" plant lice (Fig. 360) are easily recognized before the adult parasite escapes, by the inflated and discolored bodies which appear among the healthy individuals. These bodies are usually of a lighter color and finally become greatly bleached. The circular hole cut by the escaped parasite is always a sure sign of the presence of this beneficial insect. The "mummies" are fastened to the leaf, as soon as the louse is dead, by the larva of the parasite, which cuts a slit in the lower side of the body and fastens the sides to the leaf or twig by excreting a mucilaginous or weblike substance for this purpose.

Distribution.—This parasite is very common throughout the entire State.

Hosts.—It preys upon many of the common plant lice. So far it has bred from the black citrus plant louse (*Toxoptera aurantiæ* Koch), the melon aphid (*Aphis gossypii* Glover) and the green apple aphid (*Aphis pomi* De Geer).

THE BLASTOPHAGA²⁶⁵

Blastophaga psenes (Linnaeus) (Family Agaonidae)
(*Blastophaga grossorum* Gravenhorst)
(*Cynips psenes* Linnaeus)

(Fig. 264)

Description.—The adults are exceedingly small, being about $\frac{1}{16}$ inch long, the male being brown or amber and the female shiny black in color. The female is winged, has large compound eyes and three ocelli, ten-articled antennæ, well developed gnawing mouth-parts and sharp ovipositor, which, when fully extended, is exceedingly long. The male is always wingless, has small compound eyes and no ocelli. The eggs are white, elliptical, with a short petiole and exceedingly minute. The larvæ are legless and white with brown mandibles. They are exceedingly small.

Life History and Work.—This very important beneficial insect is propagated only in certain non-edible figs, known as caprifigs. In these the females lay their eggs in the ovaries of the flowers, by pushing the ovipositor down through the hollow style. The ovaries inhabited by the larvæ are called galls; as in them the insects feed and develop. The males issue first and crawl about over the galls. With their power-

²⁶⁵The writer is indebted to Mr. G. P. Rixford, Bur. Plant Industry, U. S. Dept. Agric., for this information regarding *Blastophaga psenes* (Linn.)

ful jaws they gnaw holes in those containing the females, through which the abdominal projection is inserted and mating accomplished. Next day the mature and fertilized females enlarge the openings and crawl out. Leaving the fig, by the eye, they enter the next crop of figs on the same capri tree, which is in a more receptive condition, unless the caprifigs containing the mature insects are hung in the Smyrna trees. In the latter case they enter the Smyrna figs. They wander about in a vain effort to get rid of their eggs, and in doing so distribute the pollen adhering to their bodies to the female flowers and then crawl out of the fig.

The capri tree, the crop of which is the only one in which the insect can lay its eggs, on account of the shape of the flowers, produces three distinct crops, called, respectively, mamme, profichi and mammoni. The first, the overwintering crop, contains no pollen and can not, therefore, be used to fertilize the Smyrna figs. The profichi contain an abundance of pollen, which is available at the time the insect reaches maturity, and as at this time (Jupe) the young Smyrna figs are in a receptive condition, it is the one used to pollinate the Smyrna crop. As the Smyrna fig will not develop to maturity without pollen and as the flowers are inside the fig, some method must be used to carry the pollen to them. For this purpose the *Blastophaga* is utilized, and the act of placing the caprifigs on the female trees is called caprification. The whole Smyrna fig industry is absolutely dependent upon this process. In order to provide a supply of the *Blastophaga*, caprifigs are planted convenient to the commercial fig orchards. These caprifig trees usually hold their fruit during the winter. Occasionally, however, severe frosts destroy the overwintering caprifigs and the *Blastophaga* perishes with them. To avoid such losses, the mamme crop of caprifigs, in which the *Blastophaga* hibernates in the larval stage, may be picked in December and packed in layers in boxes of clean, damp sand and kept in a place where the temperature is about 55 or 60 degrees Fahr. In the spring these figs are taken to the caprifigs and the *Blastophaga* allowed to issue when the young caprifigs are ready for fertilization, which is about April. At this time the profichi crop is receptive. This crop is exceedingly rich in pollen, which sticks to the bodies of the females and is carried thus into the Smyrna figs.

Distribution.—This insect is now distributed throughout the commercial fig-growing sections of the State, which are practically confined to the Sacramento and San Joaquin valleys.



Fig. 364.—The *Blastophaga*, *Blastophaga psenes* (Linn.). Winged females, apterous males and the ovaries or galls inhabited by the larvæ. Enlarged four times. (Original)

THE CLOVER SEED CHALCIS

Bruchophagus fanchris Howard (Family Eurytomidae)

(Fig. 365)

Description.—From the fact that this insect works within a clover seed, it must be very small in size, being from $\frac{1}{16}$ to $\frac{1}{12}$ inch long. The adults are black with dark brown eyes and light brown feet. The eggs are polished white and slightly elongated, with a long, slender pedicle at one end. The larvæ are white and just large enough to fill the empty shells of the seeds. The pupæ are first white, afterwards

changing to brown. The entire life cycle, from the egg until the adult emerges, is spent within the seeds, the contents of which are completely devoured by the larvæ. Occasionally a larva may work upon several different seeds.

Life History.—The winter is spent in the seeds, either as larvæ or pupæ. About blooming season the adults emerge and begin egg-laying. The eggs are inserted within the forming seeds by the ovipositor. There are probably several generations each year.

Nature of Work.—The larvæ eat out the inside of the seeds, in which pupation takes place. The adults emerge through circular holes cut in the ends or sides of the shell, as shown in Fig. 365.

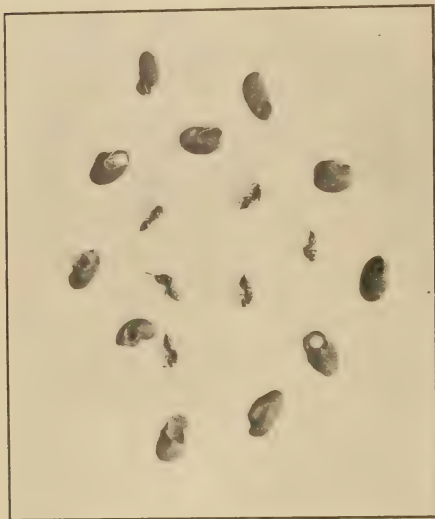
Fig. 365. The clover seed chalcis, *Bruchophagus fanchris* How. Adults and alfalfa seeds from which they have issued. Enlarged four times. (Original)

The seeds are either entirely eaten out or rendered worthless and are usually blown off with the chaff, so that damage may pass for years unobserved.

Distribution.—Although this insect is reported as existing in all parts of the State where clover and alfalfa seed are raised, due to its small size the pest may exist for some time in a locality without being discovered.

Food Plants. The clover seed chalcis has been reported as working upon the seeds of red and crimson clover and alfalfa.

Control.—So far this pest has received little or no attention, there being no requests for help, but nevertheless great damage is being done.



This is unfortunate, as control measures are difficult and poorly worked out. Pasturing the fields or destroying all clover and alfalfa heads in the winter, as well as the destruction of the straw after threshing, are the check measures recommended. Infested seed should not be sown.

THE WHEAT JOINT-WORM

Isosoma tritici Fitch²⁶⁶ (Family Eurytomidae)

(Figs. 366, 367)

Description.—The adults are very small, shiny-black, four-winged insects. The joints of the legs, feet and two spots on the shoulders are yellow. The females are about $\frac{1}{8}$ inch and the males 1-9 inch long. The full-grown larvæ or grubs are legless, yellowish or whitish with brown mouth parts and about $\frac{1}{16}$ inch long. The pupæ are about the same size as the larvæ and at first the same color, but gradually become darker as they mature.



Fig. 366.—Adult of the wheat joint-worm, *Isosoma tritici* Fitch. Natural size is shown by the line at the right. (After Howard, U. S. Dept. Agric.)

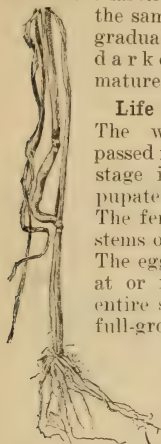


Fig. 367.—Wheat stem showing the work of the wheat joint-worm, *Isosoma tritici* Fitch. Reduced. (After Webster, U. S. Dept. Agric.)

Life History. —

The winter is passed in the larval stage in cells within the stems of the wheat. The larvæ pupate in the spring and issue as adults in April and May. The females deposit their eggs in the uppermost joints of the stems of the growing wheat, by means of the sharp ovipositor. The eggs hatch very soon and the larvæ feed within the stalks at or near the joints, producing knots or swellings. The entire summer is spent within the stems, the larvæ becoming full-grown when the grain ripens. The cells for hibernation are made at this time. There is but a single brood a year.

Nature of Work.—The work of the wheat joint-worm is very characteristic and consists of various knots, swellings or other distortions of the stems near or between the joints. An angle of thirty degrees may be formed in the main stalk at the place of attack. The stems become very brittle at these points and break easily. Thus much of the wheat may fall before harvest time. In threshing, hard, broken bits of the straw remain with the wheat, greatly reducing its value.

Distribution.—This insect was reported at Sacramento as early as 1895.²⁶⁷ Woodworth²⁶⁸ also lists it in his work on California insects. However, the insect does not appear to be a serious pest in California.

²⁶⁶Prof. R. W. Doane reports to have collected this fall (1914), in Shasta County, what he believes to be the larvæ of the wheat straw-worm, *Isosoma grande* Riley.

²⁶⁷Rept. Cal. Agrcl. Exp. Sta., p. 245, 1894-5.

²⁶⁸Woodworth, C. W., Guide to Cal. Insects, p. 120, 1913.

Food Plants.—Wheat appears to be the only recorded host plant of this insect.

Control.—Since the larvæ hibernate in the straw or stubble in the field, it is very important to cut the grain as low as possible and to plow the stubble under deep. The straw from the infested fields should be burned during the winter, as the larvæ mature as well in the mow as in the field. Crop rotation is also recommended. In controlling this pest it is important for whole sections to cooperate in the methods adopted. Not nearly as much can be accomplished by a single individual as by a community.

Natural Enemies.—In his work on this pest, J. S. Houser²⁶⁹ records the following natural enemies: The hymenopterous parasite (*Ditropinotus aureoviridis* Crawford), the predaceous mite (*Pediculoides ventricosus* Newport) and the fungous disease (*Sporotrichum globuliferum*). All of these attack the larval and pupal forms.

Aphycus sp. (Family Encyrtidæ)²⁷⁰

(Fig. 368)

Description.—This is a small, yellow, four-winged insect as shown in Fig. 368.

Distribution.—It is especially abundant in the southern part of the State and also found in the central and northern parts.

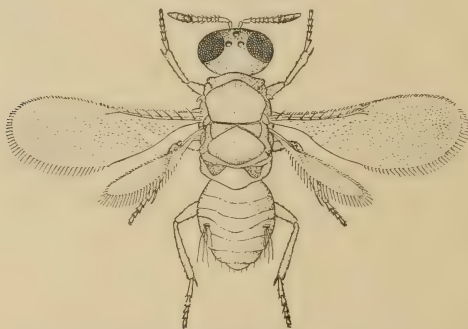


Fig. 368.—*Aphycus* sp. which commonly attacks the soft brown scale, *Coccus hesperidum* Linn. Greatly enlarged adult. (After Howard, U. S. Dept. Agric.)

Hosts.—This species is a very important enemy of the soft brown scale (*Coccus hesperidum* Linn.), and when abundant is a very efficient check to this pest. It also occasionally attacks immature forms of the black scale, *Saissetia oleæ* (Bern.).

²⁶⁹Bul. 226, Ohio Agrcl. Exp. Sta., pp. 196–198, 1911.

²⁷⁰This species has been commonly known as *Aphycus flavus* (Howard), but according to P. H. Timberlake it is *Aphycus* sp. near *flavus*. (Jr. Ec. Ent. VI, pp. 294–295, 1913).

Aphyus immaculatus Howard (Family Encyrtidae)

(Fig. 369)

Description.—This is a small dark parasite, slightly over $\frac{1}{50}$ inch in length. The general color is dark yellowish-brown with light yellow head, dusky legs and antennæ and hyaline wings.

Distribution.—So far as known, this species occurs only in the southern part of the State.

Hosts.—It is parasitic upon the red scale, *Chrysomphalus aurantii* (Mask.).



Fig. 369. — *Aphyus immaculatus* How. Female, greatly enlarged. (After Howard, U. S. Dept. Agric.)

THE CITRUS MEALY BUG PARASITE

Chrysoplatycerus splendens Howard (Family Encyrtidae)

(Fig. 370)

Description.—This very small parasite is but $\frac{1}{15}$ inch long. It is easily distinguished by its iridescent black color, shiny scutellum and large antennæ. The scutellum has a very noticeable tuft of bristles



Fig. 370.—The citrus mealy bug parasite, *Chrysoplatycerus splendens* How. Dorsal and lateral view of adults. Greatly enlarged. (Author's illustration, P. C. Jr. Ent.)

at the apex. The pointed abdomen also has a tuft of bristles upon each side. The apical two thirds of the fore wings are very black, while the basal third and the hind wings are lighter.

Life History.—The female is rather deliberate in her actions and may remain in a very small area for an hour or so, all the time busy examining the host. In doing this she holds her antennæ as is shown

in the lateral view in Fig. 370, and does all of the feeling with the tips. These she moves very rapidly and when a suitable host has been found turns around and punctures it with the ovipositor and deposits the egg. From observation it is very probable that she deposits but one egg in an individual. When touched or disturbed she jumps and may even fly away. She rests with the body close to the supporting fruit or leaf, with the legs spread out at the sides and the antennae flattened out in front, not unlike two long front legs. It was possible to obtain a large number of these internal parasites from small breeding cages filled with adult mealy bugs and their egg masses, but the good they do is very difficult to estimate. Great numbers were kept confined for a year, but the number of mealy bugs increased enormously while the parasites almost entirely disappeared. In mounting hundreds of adult mealy bugs I have been unable to procure one that contained the larval form of the parasites, but the empty skins from which the adults issued are plentiful on the trees in the orchards.

Distribution.—This parasite is found in the southern part of the State and reported only in Ventura County.

Hosts.—The only recorded hosts are half-grown and adult mealy bugs, *Pseudococcus citri* (Risso).

THE PARASITE OF THE EUROPEAN FRUIT LECANIUM

Comys fusca Howard (Family Encyrtidae)

(Fig. 371)

Description.—The adults of this parasite are about $\frac{1}{8}$ inch long and rich brown throughout in color. The wings are clouded with brownish markings, the bases remaining clear and when folded over the back form a silver-like spot which is very noticeable when the insect is walking. The veins are black. The tips of the legs are yellowish with dark claws.



Fig. 371.—The European fruit Lecanium parasite, *Comys fusca* How. Adult female greatly enlarged. (Drawing by Birdnekoﬀ, Mo. Bul. Cal. Hort. Com.)

ish markings, the bases remaining clear and when folded over the back form a silver-like spot which is very noticeable when the insect is walking. The veins are black. The tips of the legs are yellowish with dark claws.

Distribution.—This is one of the most common parasites, occurring in all parts of the State.

Hosts.—Of all the internal parasites of scale insects, this is one of the most efficient and is often quite a controlling factor in keeping down the European fruit Lecanium (*Lecanium corni* Bouché). The writer has also reared this parasite

from the frosted scale (*Lecanium pruinosum* Coq.) and a native scale (*Lecanium* sp.) in Ventura County. The hemispherical scale is also recorded as a host.

THE KATYDID EGG PARASITE

Eupelmus mirabilis (Walsh) (Family Encyrtidae)

Description.—The adult parasites are a little more than $\frac{1}{8}$ inch long and of a metallic green color. The wings are dusky. The insect has a peculiar way of elevating the abdomen over the thorax.

Life History.—The eggs are deposited within the eggs of the katydid by the female. The entire contents of the eggs are devoured by the larvæ, and the transformations to adults occur within the shells, the adults issuing through circular holes in the sides. (Fig. 29.)

Distribution.—It is common throughout the entire State.

Host.—This parasite works upon the eggs of the angular-winged katydid (*Microcentrum laurifolium* Linn.) and *Scudderia* spp.

PARASITE OF THE SOFT BROWN SCALE

Microterys flavus (Howard) (Family Encyrtidae)

(*Encyrtus flavus* Howard)

(Fig. 372)

Description.—This is a small parasite scarcely $\frac{1}{16}$ inch long. The general color of the female is ochre; compound eyes, brown; ocelli, red; antennæ, yellow with tips black; the tips of the feet, black. The basal third of the fore wings is clear with the remainder clouded with brown; the hind wings are clear. The males are considerably smaller than the females and shiny metallic-green in color with legs and antennæ very light; wings, clear with brown veins.

Distribution. — It is quite common throughout the State, but especially abundant in the southern part.

Hosts. — This parasite has been reared from the soft-brown scale (*Coccus hesperidum* Linn.), which is often very effectually checked by its attacks.

THE BLACK SCALE PARASITE

Dilophogaster californicus (Howard) (Family Pteromalidae)

(*Tomocera californica* Howard)

Description.—The females are slightly more than $\frac{1}{16}$ inch long. The general color is metallic bluish-black, with head, base of antennæ and



Fig. 372. — *Microterys flavus* (How.), parasite of the soft brown scale. Greatly enlarged. (Drawing by Bird-nekoff, Mo. Bul. Cal. Hort. Com.)

the undersides of the legs rich reddish-brown; thorax metallic black; abdomen metallic bluish-black with brown spot near the base; upper portions of legs and tips of antennæ black and the latter distinctly hairy. The wings are dark with short fringes. The males are metallic black; bases of antennæ brown and tips black; all parts of legs, except black hind tibiæ, are amber; wings perfectly clear.

Distribution.—The black scale parasite is abundant in most of the southern citrus growing sections of the State.

Hosts.—The larvæ work upon the eggs and young of the black scale, *Saissetia oleæ* (Bern.). In the year 1913, Mr. R. S. Vaile, then Horticultural Commissioner of Ventura County, reported that this parasite had wrought great execution upon the black scale in certain citrus orchards near Ventura.

THE SCUTELLISTA

Scutellista cyanea Motschulsky (Family Pteromalidæ)

(Fig. 373)

Description.—The adult is a small four-winged parasite, less than $\frac{1}{2}$ inch long, robust and metallic steel-blue to nearly black in color.

Life History.—The small, oblong, white eggs are placed under the black scales. They are somewhat larger than the eggs of the scales and hatch in from five to six days into crescent-shaped, white, legless larvæ, which feed upon the eggs of the black scale for fifteen to twenty days, when they pupate, and after another like period emerge as adults from the shells of the scale through circular holes cut for this purpose. The adult lives a little over a week.

Distribution.—The *Scutellista* occurs throughout the State, where the black scale is found in any considerable numbers.

Hosts.—This parasite was introduced from Africa, to prey upon black scale, *Saissetia oleæ* (Bern.). It often becomes very abundant, attacking upwards of 90 per cent of the scale, but it has nowhere diminished the scale to an appreciable extent, and does not anywhere prevent the necessity for fumigation. It also works on the hemispherical scale, *Saissetia hemisphærica* (Targ.).

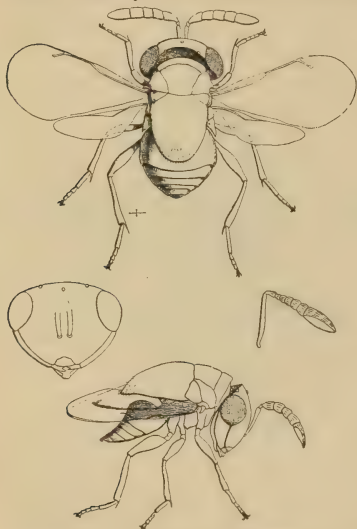


Fig. 373.—The *Scutellista*, *Scutellista cyanea* Motsch. Adults, face and antenna, very greatly enlarged. (After Howard, U. S. Dept. Agric.)

THE GOLDEN CHALCID

Aphelinus diaspidis Howard (Family Eulophidæ)

(Fig. 374)

Description.—The adults are exceedingly small and delicate, bright yellow insects.

Distribution.—This species is common throughout the southern part of the State, though it probably occurs in many central and northern sections.



Fig. 374.—The golden chalcid, *Aphelinus diaspidis* How. Adult, greatly enlarged. (After Howard, U. S. Dept. Agric.)

Hosts.—It is parasitic upon the red scale, *Chrysomphalus aurantii* (Mask.), and the rose scale, *Aulacaspis rosæ* (Bouché).

PARASITE OF THE OYSTER-SHELL SCALE

Aphelinus mytilaspidis LeBaron (Family Eulophidæ)

Description.—The adult parasites are exceedingly small, being about $\frac{1}{32}$ inch long. The color is bright lemon-yellow; the base of antennæ, dusky; the eyes, dark; the ocelli, red; the mandibles, brown; the legs and wing veins, bright yellow.

Distribution.—This species is quite common throughout the State.

Hosts.—The parasite preys upon a number of scales, among which are the oyster-shell scale, *Lepidosaphes ulmi* (Linn.), the pine-leaf scale, *Chionaspis pinifoliæ* (Fitch), the pernicious scale, *Aspidiotus perniciosus* Comst. and *Diaspis carueli* Targ.

THE PURPLE SCALE PARASITE

Aspidiotiphagus citrinus (Craw) (Family Eulophidæ)

(Fig. 358)

Description.—The purple scale parasite is an exceedingly small insect, almost microscopic in size, light and brownish-yellow in color with wings, antennæ and legs pale yellow.

Distribution.—This parasite is generally distributed throughout the purple scale-infested citrus districts in the southern part of the State, but is often limited or totally absent in certain localities. It is most abundant in San Diego County.

Hosts.—It works uncertainly, but often very effectually, on purple scale, *Lepidosaphes beckii* (Newm.), in small localities, but of little

consequence in controlling this pest. It also works on yellow scale, *Chrysomphalus citrinus* (Coq.), red scale, *Chrysomphalus aurantii* (Mask.), and pernicious scale, *Aspidiotus perniciosus* Comst.

THE LECANIUM PARASITE

Coccophagus lecanii (Fitch) (Family Eulophidæ)

(Fig. 375)

Description.—The adults are scarcely $\frac{1}{8}$ inch long, dark bluish-black in color with a very noticeable and characteristic yellow scutellum. The antennæ and the legs, excepting the dark femora, are amber.

Distribution.—It is exceedingly common throughout the entire southern and central parts of the State.

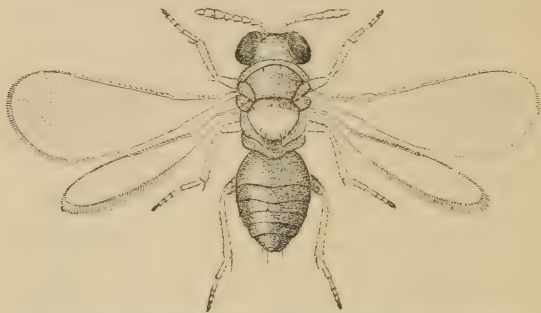


Fig. 375.—*Coccophagus lecanii* (Fitch). Adult greatly enlarged.
(After Howard, U. S. Dept. Agric.)

Hosts.—This is a very effective parasite on the younger stages of the soft brown scale, *Coccus hesperidum* Linn., the European fruit Lecanium, *Lecanium corni* Bouché, and the frosted scale, *Lecanium pruinosum* Coq. In fact, it may be reared from almost any of the members of the above genera.

THE RED SCALE PARASITE

Coccophagus lunulatus Howard (Family Eulophidae)

(Fig. 376)

Description.—This is a very minute parasite, less than 1-25 inch long. The general color is black; apical two thirds of scutellum,



Fig. 376. — The red scale parasite, *Coccophagus lunulatus* How. Female greatly enlarged. (After Howard, U. S. Dept. Agric.)

orange with black tips; antennae, dark; legs, yellow with hind femora dusky in middle and wings, hyaline with dark brown veins.

Distribution.—The species occurs in the southern part of the State.

Host.—It is parasitic upon red scale, *Chrysomphalus aurantii* (Mask.).

Prospaltella aurantii Howard (Family Eulophidae)

[*Prospalta aurantii* (Howard)]

(*Coccophagus aurantii* Howard)

(Fig. 377)

Description.—This is a very small, brownish-yellow parasite with black compound eyes, red ocelli, reddish legs and dusky wing veins.

Distribution.—It was first discovered by D. W. Coquillett at San Gabriel, California, in 1887, and is more or less generally distributed in the southern part of the State.

Hosts.—This species is parasitic on the yellow scale, *Chrysomphalus citrinus* (Coq.), in California, but has also been reared from the purple scale, *Lepidosaphes beckii* (Newm.), *Aspidiotus ancyclus* (Putn.), the walnut scale, *Aspidiotus juglans-regiae* Comst., *Lecanium persica*



Fig. 377.—*Prospaltella aurantii* How. Adult, greatly enlarged. (After Howard, U. S. Dept. Agric.)

(Fab.) and *Chionaspis* spp.

WHITE FLY PARASITE

Pterotrix flavimedia (Howard) (Family Eulophidæ)*(Gyrolasia flavimedia* Howard)

(Fig. 378)

Description.—This is an extremely minute parasite about 1-25 inch long. The general color is rich metallic black, the second and last abdominal segments being bright orange with bases of antennæ, the legs and the under side of the abdomen yellow. The fore wings are clear with a distinct dark spot near the middle of the front margin. The veins are black.



Fig. 378. — The white fly parasite, *Pterotrix flavimedia* (How.). Adult, greatly enlarged. (After Howard, U. S. Dept. Agric.)

Distribution.—The white fly parasite exists throughout the State. It is specially abundant at Berkeley and Oakland.

Host.—This species is parasitic on *Aleyrodes spiraeoides* Quaint.

THE YELLOW SCALE PARASITE

Signiphora occidentalis Howard (Family Eulophidæ)

(Fig. 379).

Description.—This is one of the smallest parasites, being scarcely over 1-50 inch in length and rather robust. The general color is dark brown or nearly black; eyes, dark red; mesonotum, yellow; legs and antennæ, amber; wings, dusky with long fringe; forewings with indefinite dark blotch near the middle.

Distribution.—The yellow scale parasite occurs in the southern part of the State. It does not seem to have been recorded in the northern and central parts.

Host.—It is parasitic on the yellow scale, *Chrysomphalus citrinus* (Coq.).

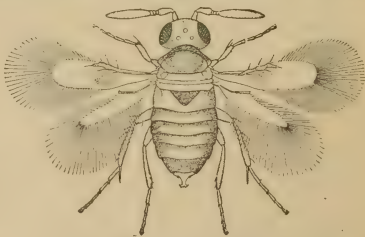


Fig. 379.—The yellow scale parasite, *Signiphora occidentalis* How. Adult, greatly enlarged. (After Howard, U. S. Dept. Agric.)

THE ARGENTINE ANT²⁷¹*Iridomyrmex humilis* Mayr (Family Formicidae)

(Fig. 380)

Description.—The adult workers are small, dark-brown ants, living in small or very large colonies. There are two other adults forms: queen and male. The queen is $\frac{1}{2}$ inch long, with the legs slightly longer than the abdomen. The body is covered with silky pubescence. She lays from two to fifty eggs a day. The worker is much smaller, being only about half as large as the queen. There is but one caste of long-lived workers. The male is a little larger than the worker, varying from $\frac{1}{8}$ inch to $\frac{1}{4}$ inch in length. The thorax, like that of the queen, is noticeably enlarged, supporting four wings, the abdomen small and the head short and blunt. This sex appears in the spring. The eggs are elliptical, very small, pearly white and smooth, with a very thin membrane which allows the developing embryo to be clearly seen.

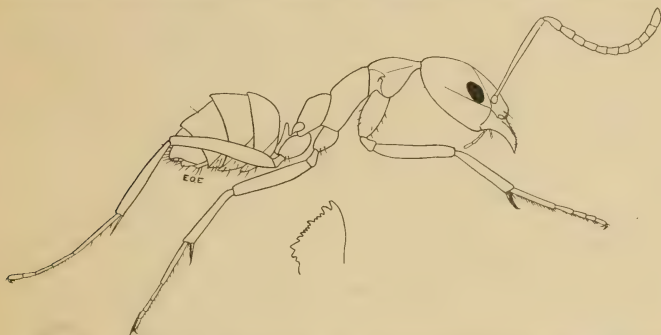


Fig. 380.—Worker of the Argentine ant, *Iridomyrmex humilis* Mayr, and detail of a mandible, showing the arrangement of the teeth. Greatly enlarged. (Original)

Life History.—The eggs hatch in from eighteen to fifty-five days. The larvæ are fed by attending workers for about thirty-one days during the summer, before they become full grown. As the pupæ develop they become darker until they approach the color of the emerging adults. This stage requires about fifteen days. The entire life cycle for the worker to the beginning of the adult stage averages about seventy-eight days. Egg laying begins in the spring and continues until winter.

Nature of Work.—The work of the Argentine ant differs somewhat in the various localities, but the insect is a serious household pest in all. It invades the hives of honey bees and completely destroys or drives away the bees. Probably the most serious problem in connection with the Argentine ant in the Southern States is the protection which it is said to give to scale insects and plant lice. The ants constantly attend scale insects and plant lice, and thus keep away all forms of preda-

²⁷¹Newell, Wilmon, Jr. Ec. Ent. II, pp. 172-174, 1909.

Woodworth, C. W., Bul. No. 207, Cal. Agrol. Exp. Sta., 1916.

Newell, Wilmon, and Barber, T. C., Bul. No. 122, Bur. Ent. U. S. Dept. Agric., 1913

ceous and parasitic insects. Consequently, these insects increase in sufficient numbers to do much damage in the orchards, particularly the orange groves. In California this condition is not very evident, except perhaps with the soft brown scale, but with the increase of the ant a very serious and new problem may face the citrus fruit growers. The author has observed the ants in Berkeley attending colonies of the black cherry aphid (*Myzus cerasi* Fab.) on cherry trees, there being myriads of the ants present. They are also troublesome in the chicken yards to setting hens and to hatching chicks, often swarming over them in numbers sufficient to cause death. If one can imagine an ant many time more troublesome and prolific than the native house and field ants, much more aggressive and persistent and capable of bothering nearly everything, he gets a fair idea of the Argentine ant. It appears to be little less than a scourge to a community.

Distribution.—Professor C. W. Woodworth lists the following localities in the State as infested with the Argentine ant: Alameda, Azusa, Berkeley, Byron Hot Springs, Campbell, Claremont, College Park, Corona, Cupertino, Emeryville, Fruitvale, Los Angeles, Martinez, Melrose, Monrovia, Montecito Canyon, Oakland, Piedmont, Riverside, San Francisco, San Jose, Santa Clara, San Mateo, Stege, Stockton and Upland.

Food.—The ants are exceedingly fond of any sweetened material, which largely accounts for their invasion of houses, grocery stores, candy shops, restaurants, hotels, bee hives and their attendance upon insects which secrete honey-dew, as the scale insects, plant lice and white flies. Certain greases and fats, fresh meats, etc., are also eagerly sought by them. Many seeds, as lettuce, are even carried away. The young and adults of many insects, as bees, midges, wasps, cockroaches, etc., are greedily devoured and in destroying some of the injurious insects the ants do a good turn, but this is so insignificant, compared with the harm, that it should hardly be mentioned.

Control.—The control of this pest is exceedingly difficult. In many districts, especially in Berkeley and Oakland, Professor Woodworth has had excellent success in keeping the numbers so small that the ants ceased to be a household pest. His recommendations are given as follows²⁷²: "We obtained by far the best results by the use of a very weak solution of arsenic and syrup. Most of the commercial ant poisons commonly known as ant pastes consist of arsenic and syrup, but are made very strong in arsenic. This kills the foraging ants almost immediately. We found by reducing the arsenic to between one fourth and one eighth of one per cent they would take large quantities of the material to their nests and feed it to the young, and the whole nest would be killed by a slow poisoning.

"The most convenient way of exposing the poison to the ant's is to use a large jar with a perforated cover and within it place a sponge saturated with the arsenic solution. The ants will enter through the perforations in the cover, fill themselves with the arsenic solution and carry it to their nests. The sponge will hold enough poison to require two or three weeks to empty it, and before that time the ants will almost entirely disappear.

²⁷²Bul. No. 207, Cal. Agrcl. Exp. Sta., p. 81, 1913.

"The number of jars to use will depend upon the abundance of ants. In the worst cases a half-dozen jars will serve for an ordinary sized house and lot, and if the ants are not very bad one jar may be enough. In such cases it is well to place it in the pantry or kitchen."²⁷³

Newell and Barber have found that tape, wrapped many layers thick, with corrosive sublimate between, around the legs of bee hive stands and protected by a tight floor of the stand above and a metal shield below, to prevent wetting, serve as an excellent ant barrier for at least eleven months. The ditches used as barriers in the Southern States are hardly applicable to most sections in California. Undoubtedly by far the most efficient means of control for all purposes is the use of the slow-acting poison, as recommended above by Professor Woodworth. The prepared poison is now on sale at the druggists in the infested areas and may be had at very little expense.

²⁷³The Woodworth formula for the Argentine ant poison is as follows: Salsoda, 1 ounce; white arsenic, 1 ounce; sugar, 20 pounds, and enough water to make 3 gallons.

LEPIDOPTERA (Order)

SCALE-WINGED INSECTS

MOTHS AND BUTTERFLIES

The members of this order are among the most familiar of all insects. Nearly all of the adults have four well developed wings, which are characterized by being covered with scales or modified hairs, the arrangement of which is responsible for the varied and beautiful color pattern in so many species. The bodies are covered with fine soft hairs. All have complete metamorphoses—the larvæ being known as cutworms, armyworms or caterpillars. The mouth parts of the larvæ are for biting and chewing, while those of the adults are abortive, or for sucking.

The larvæ of a large number of species are very destructive to plant life and may be considered injurious, while of still other species they are predaceous upon other insects and are beneficial. The silkworm moth is of great commercial importance in several countries and is the most beneficial member of the order.

SPHINGIDÆ (Family)

SPHINX OR HAWK MOTHS

The adult moths of this family are primarily night-flyers, though occasionally one may be seen on dark days. Just before nightfall numbers may also be observed as they begin their night's flight. They are among the largest moths, some individuals having a wing expanse of from four to six inches, though the ones discussed here are of medium size.

The caterpillars are very large and robust, being beautifully marked with bright colors, especially with characteristic colored spots around the breathing spiracles, along the sides of the bodies.

The pupæ are very large, usually pale yellow or reddish brown and with the proboscis inclosed in the pupal skin with the body, as in the case of the white-lined sphinx, or inclosed in a separate sheath like a pitcher handle, as in the case of the tomato worm.

The caterpillars of all these moths are very destructive. Their large size and ravenous appetites enable them to devour great quantities of vegetation.

General Life History.—The winter is passed in the pupal stage of the last brood. The adults emerge early in the spring and soon begin egg laying, the eggs being usually deposited directly upon the leaves, singly or in small groups. The eggs hatch in about a week and the young caterpillars feed upon the tender foliage first. When full grown they descend from the plants and either pupate in the earth or among leaves or refuse on the surface of the ground. There are usually two broods a year, the moths of the first brood emerging about the middle of the summer, while those of the second brood do not emerge until the following spring.

Control.—Though the various members of this family are very common, it seldom happens that the young are seen in any great numbers, but individuals are not uncommon. The work is usually evident long

before the worms are detected. Because of their large size and characteristic work, they are comparatively easy to locate, and upon these facts are based the method of hand picking as a control measure. The worms are either gathered and destroyed or simply cut in two with a pair of scissors. Poison sprays will also serve to hold them in check and are being largely used to control the tobacco worm in the commercial plantings of tobacco.

THE WHITE-LINED SPHINX

Celerio lineata (Fabricius)
(*Deilephila lineata* Fabricius)

(Figs. 381, 382)

Description.—The moths are quite large, having a wing expanse of nearly $3\frac{1}{2}$ inches. The fore wings are greenish-gray with broad brown bands on the front and apical margins and in the middle of each. The veins are white. The hind wings are very small, dark brown, with a wide lighter band across the middle of each. The thorax is grayish with distinct white lines, while the abdomen is dark green, marked with black and white spots. The larvæ are quite large, often more than 3 inches long. The color varies considerably, there being two distinct forms: a light green and a black, the former being quite rare, while the latter greatly predominates. The green forms are rich green with yellow head and horn at posterior end, a row of light



Fig. 381.—Adult female of the white-lined sphinx, *Celerio lineata* (Fab.). Natural size. (Original)

and black spots along each side of the back and beautiful colored spots along the sides around the spiracles. The black forms are entirely black with a dorsal and several lateral longitudinal yellow stripes. The head and horn are also yellow. Both forms are the same size and vary from 2 to 3 inches long and $\frac{1}{2}$ inch thick. The pupæ are reddish-brown and about $1\frac{1}{2}$ inches long.

Distribution.—This is a very common moth throughout the entire State, being specially abundant in the warmer interior valleys.

Food Plants.—The caterpillars are omnivorous feeders and may be found attacking a large number of plants. Those recorded are apple,

sugar beet, buckwheat, chickweed, currant, bitter dock, elm, evening primrose, gooseberry, grape, melon, pear, plum, purslane, tomato,



Fig. 382.—The white-lined sphinx, *Celerio lineata* (Fab.). Green larva, black larva and pupa. Natural size. (Original)

turnip and watermelon. The white-lined sphinx, however, generally does little damage to cultivated plants, though in the spring of 1914 considerable injury was done to vineyards in the Sacramento Valley.



Fig. 383.—Pupæ of the achemon sphinx, *Pholus achemon* (Drury). Natural size. (Original)

THE ACHEMON SPHINX

Pholus achemon (Drury)
(*Philampclus achemon* Drury)

(Figs. 383, 384)

Description.—The moth is brownish-gray in color, with light and dark variegations and well defined dark brown spots, as shown in Fig. 384. The hind wings are rich pink with brown border and dark spots. The body is reddish-gray with two deep-brown triangular spots on the thorax. The expanded wings measure 3 or 4 inches across. The larva or caterpillar is first green, changing to reddish-brown as it grows older. The dorsum is brown with from six to eight whitish, oblique bars along the sides. The pupæ are rich brown. The eggs are globular, green and glued to the leaves.

Distribution.—This moth is common throughout the entire State, but is most troublesome in the central valleys.



Fig. 384.—Adult female of the achemon sphinx, *Pholus achemon* (Drury). Natural size. (Original)

Food Plants.—The caterpillars feed upon wild and cultivated grapevines and the Virginia creeper. The tender-leaved varieties of grapes are specially preferred and vineyards are sometimes entirely stripped of their foliage by the large numbers of the larvæ.

THE TOBACCO WORM

Protoparce quinquemaculata Haworth²⁷⁴

[*Phlegethontius quinquemaculatus* (Haworth)]

(*Sphinx celeus* Hübner)

(Fig. 385)

Description.—All forms of this species greatly resemble those of the tomato worm in size and general appearance. The lateral oblique, white stripes of the larvæ do not extend as far up the back in the tobacco worm as in the tomato worm. There are also longitudinal white stripes below the spiracles, forming "V's" with the oblique stripes. The horn at the tip of the body is black. The pupæ have a much longer tongue sheath in this species than in the tomato worm. The adults are about the same size, but those of the tobacco worm are duller with less distinct white markings. The abdomen is more pointed; the spots are lighter orange in color and two less in number than in the tomato worm.

Distribution.—The tobacco worm occurs throughout the entire State and is one of the common insects.

Food Plants.—The principal food plants of this insect are tobacco and tomato, though it feeds upon potato and various other members of the *Solanaceæ*.

²⁷⁴The latest revision of the *Sphingidae* by Hon. W. Rotinschild and K. Jordan restores this species to *Protoparce*.

Natural Enemies.—Internal parasites prey upon the larvæ and do much to keep down the numbers.



Fig. 385.—The adult female of the tobacco worm, *Protoparce quinquemaculata* Haw. Natural size. (Original)

THE TOMATO WORM

Protoparce sexta (Johanssen)²⁷⁴

[*Phlegethontius sextus* (Johanssen)]

(*Sphinx carolina* Linnæus)

(Figs. 386, 387)

Description.—The adults are about 2 inches long and have a wing expanse of from 4 to 5 inches. The general color is gray, there being

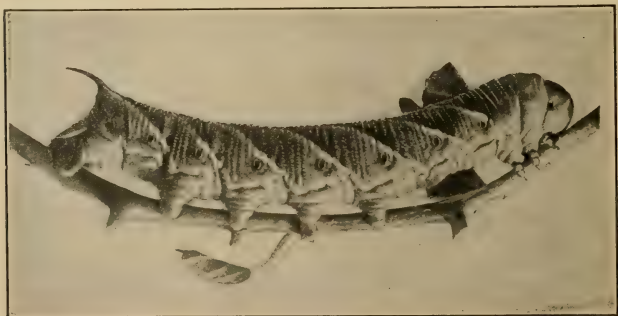


Fig. 386.—The tomato worm, *Protoparce sexta* (Johan.). Caterpillar on tomato. Natural size. (After Folsom)

a row of orange or yellow spots on each side of the abdomen. Fig. 387 shows the pattern. The caterpillars are exceedingly large, often

attaining a length of nearly 4 inches. They are light green with showy oblique white stripes and highly colored markings around the spiracles on the sides. The oblique lines serve at once to distinguish the larvæ from the green forms of the two-lined sphinx.



Fig. 387.—Adult female of the tomato worm, *Protoparce sexta* (Johan.). The proboscis is extended to show its great length. Slightly reduced. (Original)

Distribution.—This insect is exceedingly common throughout the entire State.

Food Plants.—The larvæ feed largely upon tomato plants, often defoliating large areas. They also attack potato, tobacco and various other *Solanaceæ*.

Natural Enemies.—Internal parasites perform an important part in the control of this pest and are probably responsible for the comparatively small amount of damage done.

THE BROWN DAY MOTH

Pseudohazis eglanterina Boisduval (Family Saturniidae)

(Figs. 388, 389)

Description.—The eggs are salmon-colored and laid in clusters around small stems or branches, as shown in Fig. 388. The larvæ are

dark or nearly black with fine lateral red stripes and red spots on the dorsum. The bodies are covered with branched spines, the upper row being short and rosette-like. When full-grown they are a little over 2 inches long. The chrysalids are dark reddish-brown and about 1 inch long. The adults are beautiful yellow moths, blended with red or salmon color and regularly marked with black, as shown in Fig. 389. The thorax is deep orange; the dorsal half of the abdomen is yellow and the ventral half red. A black band encircles each segment. The posterior end has a long tuft of yellow and red hairs.



Fig. 388.—The brown day moth, *Pseudohazis eglanterina* Boisd. Pupa, larva and hatched eggs. Enlarged one and one fourth times. (Original)

The antennæ of the female are orange, and those of the male brown. The legs are yellow with black spines.

Life History.—The eggs are laid in the spring upon various fruit trees, wild trees and bushes. The young attack the foliage, often entirely or almost entirely defoliating the plants. When full-grown the larvæ seek the ground, where they pupate and thus pass the winter, emerging early in the spring as adults. These are often seen flying during the day.

Nature of Work.—The caterpillars feed upon the young buds and leaves.

Distribution.—This moth occurs throughout the entire State, but is more abundant in the Sierra foothills and in the Sacramento and San Joaquin valleys, in the central part and in the San Bernardino and San Jacinto mountains, in southern California.

Food Plants.—This species attacks a great variety of both wild and cultivated trees and shrubs. Prune trees have often been severely injured, the young larvæ destroying the first appearing buds.

Control.—The egg masses are very conspicuous and great numbers of them may be easily destroyed by hand picking during the spring.

Arsenical sprays, applied when the larvæ become apparent, are also effective.

Natural Enemies.—Internal hymenopterous parasites perform a very important rôle in checking the ravages of this pest. Caterpil-



Fig. 389.—Adult male and female of the brown day moth, *Pseudohazis eglanterina* Boisd. Natural size. (Male, author's illustration, Mo. Bul. Cal. Hort. Com.; female, original)

lars are often found with the cocoons of these parasites attached to the bodies. The eggs are also destroyed in large numbers by small parasites.

THE YELLOW BEAR CATERPILLAR

Diacrisia virginica (Fabricius) (Family Arctiidae)

[*Spilosoma virginica* (Fabricius)]

(Fig. 390)

Description.—The moths have pure white heads, thorax and wings with black eyes and usually two small black spots on each of the wings. The abdomen is orange-yellow, marked with white and four or five rows of black spots. The antennæ and legs are white with black markings and the front legs are also profusely marked with orange. The average length is about $\frac{5}{8}$ inch and the wing expanse

about $1\frac{3}{4}$ inches. The caterpillars are easily recognized by the long light-yellow or dark-brown hairs on the bodies. The cocoons are made almost wholly out of the hair of the larvæ. The pupæ are dark brown and $\frac{5}{8}$ inch long. It is also called the Virginian tiger moth.

Life History.—The caterpillars appear in the spring, often in great numbers, and feed upon all kinds of vegetation. When full-grown, which requires about one month, they spin frail cocoons of their own hair, in which to pupate. The winter is spent in the pupal stage. There are two broods a year.

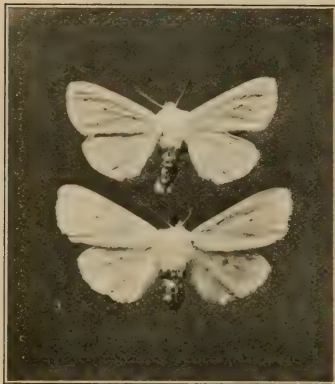


Fig. 390.—Adult male and female of the yellow bear caterpillar, *Diacrista virginica* (Fab.). Natural size. (Original)

Nature of Work.—The caterpillars eat the foliage of low-growing and succulent trees and shrubs and may entirely devour the tender plants.

Distribution.—The distribution of the yellow bear caterpillar is quite wide, but it is usually confined more to the southern part of the State.

Food Plants.—The caterpillars are omnivorous feeders and have been reported as attacking the following: alfalfa, asparagus, beans, beets, blackberry, cabbage,

canna, carrot, cauliflower, celery, cherry, corn, currant, dahlia, dock, eggplant, gooseberry, grape, hollyhock, hyacinth, lambsquarters, morning-glory, muskmelon, onion, parsnip, peas, peanut, pigweed, potato, pumpkin, radish, ragweed, raspberry, rhubarb, Russian thistle, *Solanum* spp., Spanish needle, squash, sunach, sunflower, sweet potato, turnip, violet, watermelon and various other plants.

Control.—The application of strong arsenical sprays are recommended to protect trees and shrubbery. Cultivated plants have been treated by applying a rather expensive spray composed of Paris green, 10 pounds; lime, 10 pounds, and water, 100 gallons, using about 100 gallons to the acre.²⁷⁵ Neutral lead arsenate, 4 pounds to 100 gallons of water, will doubtless give as good results. Clean culture and burning over waste areas during the winter are also recommended.

THE SPOTLESS FALL WEB-WORM

Hyphantria texator Harris (Family Arctiidae)

(Fig. 391)

Description.—The adults are slightly over $\frac{1}{2}$ inch long and with a wing expanse of $1\frac{1}{2}$ inches. The body is pure white, with yellow markings. The antennæ are white and the abdomen is without black spots. The last two characters separate the species from the fall web-worm, *Hyphantria cunea* (Drury), of the Eastern States. The full-

²⁷⁵Marsh, H. O., Bul. No. 82, pt. V, Bur. Ent., U. S. Dept. Agric., pp. 62–63, 1910.

grown caterpillars are very hairy, yellowish or greenish in color, with a darker stripe along the back and a yellow stripe along each side. The body is covered with whitish hairs, which arise from black and orange-yellow tubercles.

Life History.—This species hibernates in the pupal stage within a cocoon attached to tree trunks, fences, rubbish or under the ground. The moths emerge in the spring, mate and, during the nights, the females deposit from four hundred to five hundred eggs in clusters upon the leaves of the food plants. The caterpillars feed in colonies and spin webs large enough to accommodate all the members. The web may embrace a large limb of a tree. When full-grown the larvæ leave the web and descend to suitable pupal quarters. There are two broods a year, the second appearing late in the summer.

Nature of Work.—The larvæ feed upon the foliage, inclosing their particular feeding places in large webs or tents for protection.

Distribution.—This introduced pest is common throughout the Sacramento and San Joaquin valleys and is the web-worm most often encountered.

Food Plants.—The spotless fall web-worm feeds upon the foliage of a great number of wild and ornamental trees and shrubs, as well as upon fruit trees. During the year 1912 much damage was done to willows in the San Joaquin Valley, while peach trees suffered in Sutter County.

Control.—The application of arsenical sprays, the collecting of the cocoons and the burning of the nests or webs containing the larvæ with a torch are the remedies usually recommended for this pest.

Natural Enemies.—Internal parasites probably play an important part in the control of this moth.

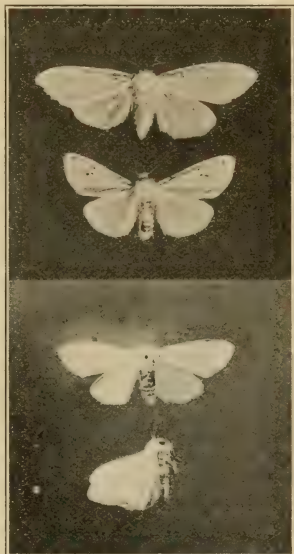


Fig. 391.—Adult female and male of the fall web-worm, *Hyphantria cunea* (Drury), at the top and female and male of the spotless fall web-worm, *Hyphantria textor* Harris, at the bottom. Natural size. (Original)

NOCTUIDÆ (Family)

ARMYWORMS AND CUTWORMS

General Life History.—The adult members of this family are practically all night-flyers. The caterpillars of many are known as cutworms and armyworms and are among the most destructive insect pests. In great numbers they often advance from field to field like

an army, devastating as they go. Like the grasshoppers, they attack practically all kinds of plants, including field and truck crops, vineyards and orchards, as well as flowers and weeds.

The eggs are laid in the spring by the adults and the larvæ become exceedingly numerous in early summer, when most of the damage is done. The pupal stage is passed underground; the light or dark-brown, naked chrysalids being housed in small earthen cells. There are several broods a year. The winter is usually spent in the pupal stage, but some adults also hibernate.

Control.—The control of these insects has afforded difficult problems for years, and even today the methods worked out do not always give the necessary relief.

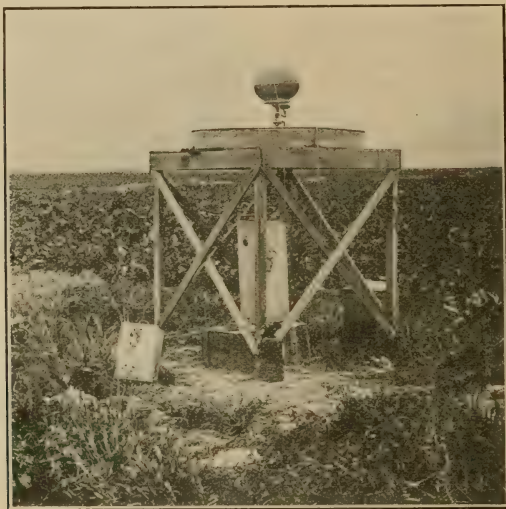


Fig. 392.—A light trap to catch moths of cutworms and armyworms used by the American Sugar Beet Company at Oxnard. Beneath the acetylene light is an oil pan into which the moths fall and are destroyed. (After Weldon)

Clean culture during the fall of the year and thorough plowing of infested fields to kill the hibernating pupæ in the cells is supposed to greatly reduce the next year's broods. This has been recommended as especially important in pea fields.

When the worms begin to march, trenches may be plowed across and ahead of their paths with a perpendicular wall in front of the advance. The worms, not being able to cross, will gather in great masses in these trenches and can be easily killed by spraying them with crude oil or by crushing them with a narrow disk or roller. Arsenical sprays applied as soon as the larvæ begin to appear will sometimes materially aid in protecting crops like potatoes, tomatoes,

young trees, grapevines, etc., but are seldom practical for forage crops.

Poisoned bait, composed of a pound of Paris green to 40 or 50 pounds of bran and sweetened either with cheap sugar or molasses, with sufficient water added to make a stiff mash, placed in the infested areas, will kill countless numbers of the worms. The citric bran mash should also be given a trial.

Light traps are also used to capture the adults, but these have never seemed to greatly lessen the attacks, because large numbers of the moths captured have previously laid their eggs.

Natural Enemies.—By far the most important factors in the control of armyworms and cutworms are natural enemies. The parasitic tachinid flies kill countless numbers of them. Hymenopterous parasites of the family *Ichneumonidæ* also prey upon the young. The predaceous ground beetles of the family *Carabidæ* devour the worms and destroy great numbers. That these insects are not injurious every year is undoubtedly due to the work of these natural enemies.

THE GREASY CUTWORM

Agrotis ypsilon (Rottemburg)

(Fig. 393)

Description.—The moths are dull reddish or brownish-gray with silvery patches at the bases and tips of the front wings. The hind wings are silvery gray, as is also the abdomen. The thorax is dark with light markings on the dorsum. The antennæ are dark and about half as long as the body. The length of the body is 1 inch and the wing expanse $1\frac{3}{4}$ inches. The caterpillars are dull-brown or nearly black with a pale broken yellowish line on the back, two faint lines on each side and a few black shining spots on each segment. The length is about $1\frac{1}{2}$ inches when full grown.

Life History.—The life history of the greasy cutworm is practically the same as for the variegated cutworm, *Lycophotia margaritosa* (Haw.).

Nature of Work.—The larvæ usually feed at night, devouring succulent growth and the foliage of hardy plants. They very often work underground and cut the plants just below the surface of the soil, thus doing great damage, especially to young plants.

Distribution.—This is a very common species throughout the State and country.

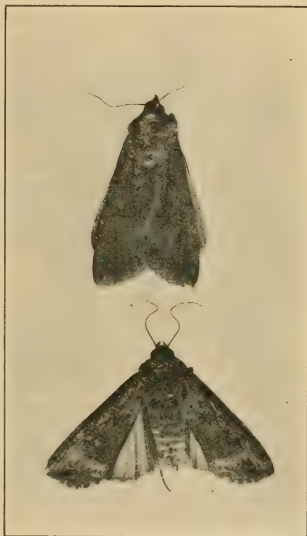


Fig. 393. — Adults of the greasy cutworm, *Agrotis ypsilon* (Rott.) Slightly enlarged. (Original)

Food Plants.—Various plants are attacked, including weeds, grasses, garden and truck crops and orchard trees. Among the plants recorded are cabbage, cotton and tomato.

Natural Enemies.—Many insects attacking other species of cutworms, as tachinid flies, internal parasites and predaceous ground beetles also prey upon the greasy cutworm. D. W. Coquillett records an instance of an adult histerid beetle (*Hister sexstriatus* Lec.)²⁷⁶ devouring the worms.

THE ALFALFA SEMI-LOOPER²⁷⁷

Phytometra californica (Speyer)

[*Autographa gamma californica* (Speyer)]

(*Plusia californica* Speyer)

(Figs. 394, 395)

Description.—The moths have a wing expanse of about $1\frac{1}{4}$ inches, with the body a little over $\frac{1}{2}$ inch long. The fore wings are light

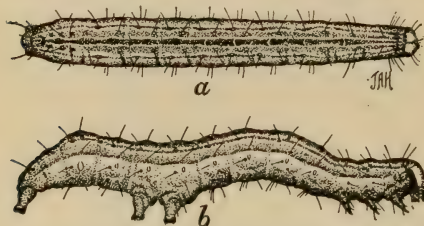


Fig. 394.—The alfalfa semi-loop, *Phytometra californica* (Speyer). Dorsal and lateral views of the larva. Enlarged two and one half times. (After Hyslop, U. S. Dept. Agric.)

bluish-gray with rose or rust-colored and light markings, a very distinctive feature of which is one shaped like the Greek letter "gamma" near the middle. The hind wings and body are dull gray. The eggs are hemispherical and pale yellow. The young caterpillars are light green, while the fully-developed forms are dark olive-green, with light green head, three dark longitudinal lines on the body and a dark spot back of each eye. There are three pairs of well-developed front legs, two pairs of abdominal legs just back of the middle and one pair at the extreme posterior end. When full-grown, the larvæ attain a length of about 1 inch. The cocoon is loosely spun of white silk, the chrysalis being brownish black, or paler in color.

Life History.—According to J. A. Hyslop, of the United States Department of Agriculture,²⁷⁷ this insect passes the winter in the pupal and adult stages. The moths appear early in the spring and are especially active, laying eggs in April, May and June in the alfalfa fields. The



Fig. 395.—Adult female of the alfalfa semi-loop, *Phytometra californica* (Speyer). Natural size. (Original)

²⁷⁶Insect Life, IV, p. 76, 1891.

²⁷⁷Hyslop, James A., Bul. No. 95, pt. VII, Bur. Ent. U. S. Dept. Agric., 1912. This insect is called a semi-loop at the suggestion of Dr. Dyar, because it is not a true loop at the Family *Geometrida*.

young larvæ are plentiful in June, feeding upon the leaves of the plants. In about two weeks they are full-grown and spin a loose white cocoon among the leaves in which to pupate. After twelve days the adult moths emerge. The entire life cycle requires about a month. There are two generations a year, the second brood appearing in July.

Nature of Work.—The caterpillars feed upon the leaves and blossoms of the alfalfa and occasionally defoliate small or large areas.

Distribution.—This moth is very common throughout the State, being specially abundant in the San Joaquin and Sacramento valleys and in the Sierra foothills.

Food Plants.—The larvæ are quite destructive to alfalfa, but also feed upon barley, cabbage, clover, dock, elder, grape, malva and peas.

Natural Enemies.—As very well shown by Mr. Hyslop, this insect is so held in check by natural enemies that artificial remedies are yet unnecessary. Internal hymenopterous parasites and tachinid flies are responsible for the good work. In the State of Washington five of the former and two of the latter have been recorded.

THE ARMYWORM

Cirphis unipuncta (Haworth)

[*Heliophila unipuncta* (Haworth)]

[*Leucania unipuncta* (Haworth)]

(*Noctua unipuncta* Haworth)

(Fig. 396)

Description.—The moths are light silvery-gray or fawn-colored with fine dark spots on the front wings, which are also darker at the tips, a dark line extending to the tips and a distinct light spot near the middle from which the specific name is derived. They are about 1 inch long. The hind wings are lighter with dusky veins and tips. The antennæ, eyes and proboscis are dark brown and the legs are marked with light and dark brown. The eggs are semi-transparent, dull white or yellowish, smooth, spherical and about $\frac{1}{100}$ inch in diameter. The full-grown larvæ are from $1\frac{1}{2}$ to 2 inches long, dark gray or blackish, with three yellowish stripes on the dorsum and a broader, darker yellow stripe on each side. The ventral surface is dusky green. The pupæ are shiny mahogany-brown with two stout spines at the posterior end.

Life History.²⁷⁸—The females begin to appear in the spring, about June, and soon deposit their eggs in rows of from two or three

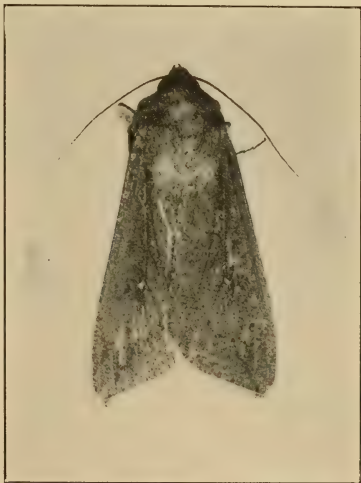


Fig. 396. — The armyworm, *Cirphis unipuncta* (Haw.). Adult female enlarged twice. (Original)

²⁷⁸Sanderson, E. D., Ins. Pests of Farm, Garden and Orchard, pp. 115-117, 1912.

to fifty in the unfolded blades of grass near the base of the plants. As many as seven hundred may be deposited by a single insect. They hatch in a little over a week and the young worms at once begin to attack green vegetation, feeding entirely by night. In from three to four weeks the larvæ are full-grown and enter the earth where a small cell is constructed and pupation takes place, the adults emerging in about two weeks. There are from three to six broods a year.

Nature of Work.—The larvæ often move together in great numbers, giving rise to the common name, armyworm. Their favorite food is the stalks and blades of grasses, but they also devour the foliage and stems of many other plants. In not a few cases the entire plants are completely devoured.

Distribution.—This insect is very common throughout the entire State.

Food Plants.²⁷⁹—Grasses are the favorite food of this species, but alfalfa, foliage of apple trees, barley, cabbage, corn, eggplant, Texas blue-grass, millet, oats, peas, pepper, potato, radish, tomato, wheat and other crops are also severely attacked.

Natural Enemies.—The internal hymenopterous parasites, *Rhogas terminalis* Cr.,²⁸⁰ *Apanteles militaris* Walsh,²⁸¹ *Hemiteles laticinctus* Riley,²⁸² *Pezomachus minimus* Walsh,²⁸³ *Mesochorus scitulus* Cr.,²⁸⁴ *Limnerium oryctus* Cr.,²⁸⁵ *Bassus scutellatus* Cr.²⁸⁶ and the red-tailed tachina fly (*Winthemia 4-pustulata*) attack this worm. Only the last one, however, occurs in California.

THE CORN EAR-WORM?²⁸⁷

Chloridea obsoleta (Fabricius)

(*Bombyx obsoleta* Fabricius)

(*Noctua armiger* Hübner)

[*Heliothis armiger* (Hübner)]

(Fig. 397)

Description.—The adult moths are day and night flyers and are exceedingly common. They are nearly 1 inch long and grayish or brownish in color, with or without markings upon the fore wings. The eggs are dirty yellowish-white in color. The larvæ are nearly 2 inches long when full-grown and vary from yellowish to brownish in color, with longitudinal gray and white stripes and with eight dark spots or tubercles on each segment. The pupæ are rich brown.

Life History.—The winter is passed by the pupæ in the soil. Adults begin to emerge in early spring and deposit their eggs upon various host plants and upon the new silk of young ears of corn. The larvæ immediately begin to feed and mature in about one month. When full-grown they enter the soil and pupate, emerging as adults in a few weeks. There are several broods a year.

²⁷⁹Insect Life, I, pp. 375-376, 1889.

²⁸⁰Insect Life, II, p. 351, 1890.

²⁸¹Insect Life, III, p. 17, 1890.

²⁸²Insect Life, III, p. 153, 1890.

²⁸³Insect Life, III, p. 154, 1890.

²⁸⁴Insect Life, III, p. 156, 1890.

²⁸⁵Insect Life, III, p. 157, 1890.

²⁸⁶Insect Life, III, p. 460, 1891.

²⁸⁷This insect is also known as the tomato worm and the cotton bollworm.

Nature of Work.—This species is perhaps most commonly known in California as the corn ear-worm, from its attacks upon the ears of corn. The larvæ enter near the silk end and destroy either the tip or the whole ear. The damage done is often enormous. The fruit of the tomato is also attacked, the worms eating large holes into the bottoms or sides, and thus causing decay. In the Southern States this species works upon the cotton bolls and is there known as the cotton boll-worm.

Distribution.—This pest is exceedingly common in all parts of the State.

Food Plants.—The following are some of the common food plants of this worm: alfalfa, beans, cabbage, clover, corn, cotton, geranium, gladiolus, grape, hemp, henbane, malva, mignonette, okra, peach, pea, pear, pepper, pumpkin, squash, strawberry, sunflower, tobacco and tomato.

Natural Enemies.—Natural enemies do little effective work in controlling this pest. The tachina fly (*Frontina armigera* Coq.) preys upon it in California.

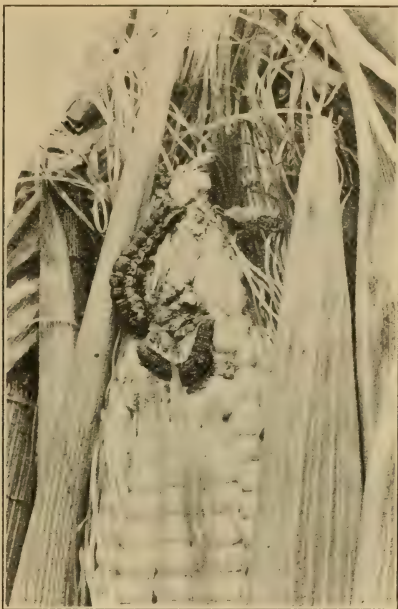


Fig. 397.—The corn ear-worm, *Chloridea obsoleta* (Fab.). Larvæ feeding on an ear of sweet corn. Natural size. (Original)

THE WESTERN ARMYWORM

Euxoa agrestis (Grote)[*Chorizagrotis agrestis* (Grote)](*Agrotis auxiliaris agrestis* Grote)

(Fig. 398)

Description.—The adult moth is about 1 inch long and dark brown with gray markings. The caterpillars or armyworms attain a length of nearly 2 inches and vary from pale-green to dark-brown.



Life History.—The life history of this species is practically the same as that of the armyworm.

Nature of Work.—The work is practically the same as that of the armyworm.

Distribution.—This species occurs in all parts of the State.

Food Plants.—The common food plants are alfalfa, beet, cabbage, celery, clover, corn, grasses, horseradish, onion, peas, potato, radish, rhubarb, tomato, fruit and forest trees and many other plants.

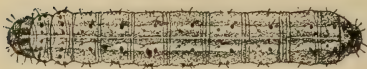


Fig. 398. — The western armyworm, *Euxoa agrestis* (Grote). Moth and larvæ. Slightly enlarged. (After Chittenden, U. S. Dept. Agric.)

THE COMMON CUTWORM

Euxoa atomaris (Smith)(*Agrotis atomaris* Smith)

(Fig. 399)

Description.—The caterpillars are light gray in color, smooth, and, when full grown, measure about $1\frac{1}{2}$ inches in length. The moth is about 1 inch long with a wing expanse of 2 inches. The color of the fore wings is almost uniform gray with paler markings, while the hind wings are much lighter.

Life History.—The eggs are laid early in April by moths recently emerged from the over-wintering larvæ and pupæ. The young caterpillars burrow into the loose soil or under the bark on the vines during the day and feed at night. When full-grown they go into the soil, transform into dark brown pupæ, and thus pass the winter in small

cells, the moths emerging the following spring. This species was exceedingly abundant and quite destructive to grapevines in the San Joaquin Valley in April, 1914.



Fig. 399.—Larvæ of the common cutworm, *Euxoa atomaris* (Smith), and work on a grape leaf. Natural size. (Original)

Nature of Work.—Besides feeding upon the foliage, as do the armyworms, the cutworms also cut off the plants just beneath the surface of the ground. This species attacks the young buds in the spring.

Distribution.—This is one of the species which attacks the buds of grapevines in the upper San Joaquin Valley. It also occurs elsewhere in the State.

Food Plants.—Though weeds and garden crops are preferred, the common cutworm is also destructive to the buds and foliage of grapes and prune trees.

THE BEET ARMYWORM

Laphygma flavimaculata (Harvey)²⁸⁸

(*Caradrina flavimaculata* Harvey)

(Fig. 400)

Description.—The adults are mottled gray with distinct light markings on the fore wings. They are about 1 inch in length, with a wing expanse of $1\frac{1}{2}$ inches. The larvæ are slender, dark green in color and distinctly striped.

Life History.—The moths appear during the months of April and June and deposit eggs, the caterpillars hatching out in May and the

²⁸⁸This species has sometimes been confused with the old world species, *L. exigua* (Hübner). (Dyar, H. T., Bul. 52, U. S. Nat. Mus., p. 110, 1902.)

last of June and becoming most abundant in August. There are probably three generations a year, the first and last doing the least amount of damage.

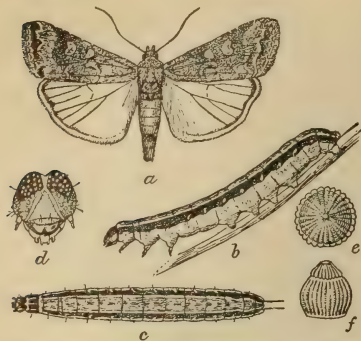


Fig. 400.—The beet armyworm, *Laphygma flavinaculata* (Harvey). *a*, moth; *b*, side view of larva; *c*, dorsal view of larva; *d*, front view of the larva; *e*, top view of egg; *f*, side view of egg. *a*, *b*, *c*, about natural size; *d*, *e*, *f*, greatly enlarged. (After Chittenden, U. S. Dept. Agric.)

THE VARIEGATED CUTWORM

Lycophotia margaritosa (Haworth)

(*Noctua margaritosa* Haworth)

[*Peridroma saucia* (Hübner)]

(*Noctua saucia* Hübner)

(Figs. 401-403)

Description.—The moths—or millers, as they are sometimes called—are grayish-brown with light markings and measuring about 1 inch in length. The cutworms are rather dull brown, mottled with gray or dark above and with a row of from four to six yellow spots on the middle of the back. They are about $1\frac{3}{4}$ inches long when fully developed. The eggs are exceedingly small, hemispherical, white and distinctly ribbed. The pupæ are reddish-brown and from $\frac{1}{2}$ to $\frac{3}{4}$ inch long.

Life History.—The eggs are laid in large, irregular masses, usually upon the stems of small plants or limbs of trees. The young worms begin to feed as soon as hatched and attack practically all kinds of vegetation, even burrowing into the ground and eating the roots and tubers, or gnawing the bark of trees. The pupal stage is passed in the soil, the chrysalis being rich brown in color and nearly 1 inch long. The winter is

Nature of Work.—The caterpillars work above ground and devour the foliage and stems of many kinds of succulent plants.

Distribution.—This insect is generally distributed throughout the State, but is more abundant in the middle and southern parts.

Food Plants.—The beet armyworm has often been a serious pest of sugar beets, but also feeds upon apple, *Atriplex*, garden beet, corn, grasses, lambsquarters, malva, onion, peas, pigweed, plantain, potato, sunflower and wild tobacco.

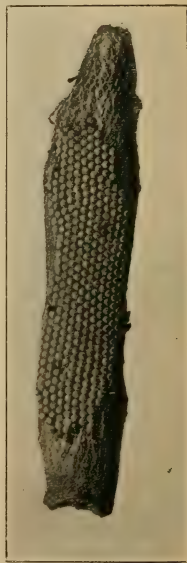


Fig. 401.—Eggs of the variegated cutworm, *Lycophotia margaritosa* (Haw.), on apple twig. Enlarged twice. (Original)

passed in the larval stage. The adults emerge early in the spring and begin egg-laying immediately.

Nature of Work.—The work of the insect is practically the same as that of the common cutworm.

Distribution.—This is one of the most common and important cutworms in this State, and occurs in all parts, being abundant in practically every section.

Food Plants.—As previously stated, this species works on practically every kind of vegetation, including forage, cereal, root and truck crops, flowers and orchard trees, while wild plants share in furnishing it food. It also



Fig. 403.—Cocoon of *Meteorus* sp., the larvæ of which emerged from the cutworm after killing it. Enlarged twice. (Original)



Fig. 402.—Larvæ of the variegated cutworm, *Lycophotia margaritosa* (Haw.). Slightly enlarged. (Original)

occasionally eats into the rind of small green oranges. Some of the recorded hosts are: alfalfa, apple, beans, barley, beet, cabbage, corn, grass, oats, peas, pear, potato, radish, tomato and wheat.

Natural Enemies.—The following natural enemies were reared from the larvæ from a single locality in Mendocino County: an internal hymenopterous parasite determined by Mr. H. L. Viereck as probably *Meteorus vulgaris* Cresson and the tachina flies, *Phorocera saundersii* Will. and *Gonia porca* Will.

THE YELLOW-STRIPED ARMYWORM

Prodenia prafica Grote

(Fig. 404)

Description.—The moths are distinctly light gray with very irregular light buff markings on the fore wings. The ground color is rich brown. Near the base is a slate-colored cross-band and a similar colored cross-band near the tips and parallel to the outer margins. The hind wings are uniformly light gray with a silvery margin. The

body and legs are light buff; the antennæ are dusky. The length is about $\frac{3}{4}$ inch; the wing expanse $1\frac{3}{4}$ inches. The caterpillars are velvety

black on the dorsum with two prominent and many delicate fine, bright yellow stripes on the sides. The ventral surface is reddish-brown. When fully-matured they are from $1\frac{1}{2}$ to 2 inches long. The pupæ are rich reddish-brown and average 1 inch long.

Life History.—Very little is known concerning the life history of this armyworm. The moths appear early in the spring and deposit eggs which soon hatch into the caterpillars. These were very abundant during May and June of 1914 and became quite destructive. Pupation takes place in the ground, beginning the last of May and adults issuing by the middle of June. There are probably two broods a year, the first spring brood being the largest and most destructive.

Nature of Work.—The work of this caterpillar is typical of that of any of the armyworms and consists in the devouring of the foliage and tender stems of the host plants.

Distribution.—The exact distribution of this pest is not well known. During the past year (1914) it has been reported from the following counties: Shasta, Sutter and Yolo. In 1913 it was received from Modoc County. It is evidently distributed

throughout the central and northern parts of the State, at least.

Food Plants.—The following food plants are reported for the years 1913-1914: alfalfa (quite seriously injured), grapevines (very seriously injured), hawthorn (slightly injured) and watermelon (seriously injured). Practically all of the damage was done between the middle of May and the middle of June.



Fig. 404. — The yellow-striped armyworm, *Prodenia praxifica* Grote. Larvæ, pupæ and adult. Slightly enlarged. (Original) -

THE CALIFORNIA OAK MOTH

Phryganidia californica Packard (Family Diopside)

(Figs. 405-408)

Description.—The adults are light brown with the antennæ and veins slightly darker. The length of the body is about $\frac{3}{4}$ inch and the wing expanse from $1\frac{1}{4}$ to $1\frac{1}{2}$ inches. The eggs are nearly spherical, being slightly flattened above. The color varies from white to pale yellowish or greenish. They are laid singly or in masses of from eight to twenty on the leaves. The full-grown caterpillars are olive-



Fig. 405. — Caterpillars of the California oak moth, *Phryganidia californica* Pack., and their work on the coast live oak. Natural size. (Photo by Leroy Childs)

green with black and prominent yellow longitudinal stripes on the sides and back and from 1 to $1\frac{1}{2}$ inches long. The head is light brown or reddish. The pupæ are shiny pale yellow with white and black markings, as shown in Fig. 407.

Life History.—There are two broods of this moth a year: one a winter and the other a summer. The winter brood hatches from eggs laid in the autumn on the leaves of the live and deciduous oak trees. The larvæ hatching from the eggs laid upon the leaves of the deciduous oaks perish when the leaves fall in the winter and only those survive which are fortunate enough to have been reared from eggs

laid on the leaves of the live oaks. Upon the leaves of the live oaks the larvæ spend the winter in an active feeding stage and transform into adults about the first of April.²⁸⁹ Eggs are laid soon after this

upon the new foliage of the deciduous oaks as well as upon the leaves of the live oak trees. These hatch into the summer brood, which is often very large and quite destructive. This brood has been responsible for repeatedly stripping the large oak trees in San Mateo and Santa Clara counties. By June large numbers of the caterpillars have become full-grown and pupate on the bark of the tree or almost anywhere in the vicinity of the infested trees. They hang by the tail and do not spin a cocoon, the body remaining perfectly naked throughout the pupal stage. In a very short time the adults appear, and after mating the females deposit their eggs upon the foliage of the oak trees.



Fig. 406.—Adult and eggs of the California oak moth, *Phryganidia californica* Pack., on leaf of the coast live oak. Natural size. (Original)

These hatch into the overwintering larvæ. Three broods have been reported,²⁹⁰ but this seems to be out of the ordinary, as there are normally but two broods, as given above.

Nature of Work.

The caterpillars devour the leaves and not infrequently completely defoliate large oak trees over considerable areas. This occurred in the summer of 1913, when hundreds of trees in Santa Clara and San Mateo counties were entirely stripped of practically every leaf.

Distribution. — This moth is most abundant in the central and southern parts of the

State, more particularly to the coast regions of Santa Clara, Santa Cruz and San Mateo counties.



Fig. 407.—Pupæ of the California oak moth, *Phryganidia californica* Pack. Slightly enlarged. (Photo by Leroy Childs)

²⁸⁹Kellogg, V. L., Ent. News, Vol. VII, pp. 174-175, 1896.

²⁹⁰Fifth Rept. U. S. Ent. Com., p. 123, 1890.

Food Plants.—The valley oak (*Quercus lobata*), the coast live oak (*Q. agrifolia*), Maul oak, black oak, cork oak and various other oaks are attacked.

Control.—Due to the large size and great numbers of the infested trees, there seems to be a feeling that successful control measures can not be employed. However, it has been demonstrated that the trees can be sprayed very easily with a good power sprayer and a woodland or ordinary nozzle and the pest successfully controlled. Lead arsenate, 4 to 5 pounds to 50 gallons of water, is recommended in the winter, as soon as the eggs begin to hatch. A second spraying should follow if the caterpillars become serious or if a large second brood appears in July or August. One spraying, however, is usually sufficient.

Natural Enemies.—Internal hymenopterous parasites play an important part in the control of this moth under certain conditions, but they do not seem to be able to cope with it under all circumstances, as shown in the last two years. A large yellow and black chalcid appears to be the most numerous. *Pimpla behrensii* Cr.²⁹¹ and *P. conquisitor* Say²⁹² also prey upon it.



Fig. 408.—Adults of the California oak moth, *Phryganidia californica* Pack. Female at top and male at bottom. Natural size. (Photo by Leroy Childs)

THE YELLOW-NECKED APPLE CATERPILLAR

Datana ministra Drury (Family Notodontidae)

(Fig. 409)

Description.—The moths are dark brown and have a wing expanse of from 1½ to 2 inches. The front wings are cinnamon-brown with three or four darker lines across each, while the hind wings are pale yellowish without markings. The eggs are ovate, white and deposited in clusters on the undersides of the leaves. The young caterpillars are dark brown with black somewhat obscure stripes. When full-grown they are 2 inches long and striped longitudinally black and yellow. The first body segment behind the head is yellow or orange-colored, which gives rise to the common name. The body is clothed with long, fine whitish hairs. When disturbed the head and tail are thrown into the air, the body being supported only by middle prolegs. The pupæ are dark brown and less than 1 inch long.

²⁹¹Doane, R. W., Jr. Ec. Ent. V., p. 346, 1912.

²⁹²Insect Life, III, p. 462, 1890.

Life History.—The winter is spent in the pupal stage and the adults emerge the following May, June or July. The eggs are deposited in masses of from twenty-five to one hundred and hatch in mid-summer. The caterpillars are gregarious and feed in large colonies, first only upon the undersides of the leaves, but later devouring all the foliage excepting the stems and midribs. They become full-grown in about one month and enter the ground from two to four inches to pupate over winter. There is but one brood a year.



Fig. 409. — The yellow-necked apple caterpillar, *Datana ministra* Drury. Dorsal view of larva on left. Right shows the characteristic attitude of the larva while feeding. Natural size. (Original)

Nature of Work.—The work of this insect greatly resembles that of the red-humped caterpillar, to which it is closely related.

Distribution.—The distribution of the yellow-necked apple caterpillar is not extensive. It has been received from Santa Clara County and exists in the central part of the State.

Food Plants.—The caterpillars feed upon the foliage of apple, apricot, blackberry, cherry, chestnut, hickory, oak, pear, plum,

prune, quince, black and English walnut and other fruit, forest and shade trees.

Control.—The remedies recommended for the red-humped caterpillar should be used for this insect.

THE RED-HUMPED CATERPILLAR

Schizura concinna (Smith and Abbot) (Family Notodontidæ)

(*Phalena concinna* Smith and Abbot)

[*Edemasia concinna* (Smith and Abbot)]

(Figs. 410, 411)

Description.—The full-grown caterpillars are reddish and have six or eight black tubercles to each segment, making them appear very dark. The body is alternately lined with white and black stripes along the back and with waved black and yellow stripes along the sides. The head is bright red, as is also the fourth segment (first abdominal segment), which is larger than any other segment, and has a distinct hump, on the top of which are four prominent black spines or tubercles. From this hump the common name is derived. The length varies from $1\frac{1}{4}$ to 2 inches when ready to pupate. The pupæ vary from tan to dark brown in color and are scarcely 1 inch in length. The adults are very plain brown or grayish moths and are seldom, if ever, seen by the grower.

Life History.—The eggs are deposited upon the leaves after the trees have put forth a good growth in early summer, May and June. The young caterpillars are gregarious in habits, feeding in compact colonies, and are thickest during June and July, but may continue to appear until late in September, showing that eggs are often laid quite late. Their work consists in destroying the foliage, the midribs of the leaves being all that usually re-



Fig. 410.—The larvæ of the red-humped caterpillar, *Schizura concinna* (S. & A.), and their work on apple. Natural size. (Original)



Fig. 411.—Adult of the red-humped caterpillar, *Schizura concinna* (S. & A.). Enlarged twice. (Original)

main. They feed rapidly and thoroughly, making the attacks easily discovered by a careful observer. Late in July and during the months following many of the larvæ become full-grown and drop to the ground, where they spin a thin cocoon and

hibernate. The cocoons are located from one to three inches under the surface of the ground, among the thickly fallen leaves, or in the grass, if it is allowed to grow in the orchard. The winter is passed in the larval stage, the pupal stage occurring in early spring, the adults emerging soon after to lay eggs when the foliage is well out.

Nature of Work.—The caterpillars feed only upon the foliage.

Distribution.—This introduced species occurs in the central part of the State.

Food Plants.—Among the food plants are apple, apricot, aspen, blackberry, cherry, hawthorn, huckleberry, pear, plum, prune and willow.

Control.—Entire colonies may be exterminated by hand picking, which is especially recommended for small trees. In large orchards, where this is impossible, arsenical sprays should be used. Hoeing or

cultivating close to the trees in the fall and winter will kill many of the hibernating forms.

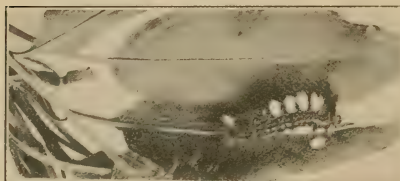
Natural Enemies.—E. J. Vosler has reared the internal hymenopterous parasites, *Apanteles* sp. and *Limnecium* sp. from the larvæ.²⁹³

THE CALIFORNIA TUSSOCK MOTH²⁹⁴

Hemerocampa vetusta (Boisduval) (Family Liparidæ)

(Figs. 412-414)

Description.—The eggs are small, oval, white and are laid in closely matted clusters, usually upon the old female cocoons. The clusters or



egg masses are nearly spherical, grayish-brown in color and between $\frac{1}{4}$ and $\frac{3}{8}$ inch in diameter. The full-grown larvæ or caterpillars vary from $1\frac{1}{2}$ to 2 inches in length. They are generally gray in color with numerous colored spots and many tufts, consisting of four prominent white ones on the dorsum and two distinct black tufts or horns on the head and one near the posterior end. The adult females are wingless and light silvery-gray in color. The males are winged and gray in color.

Life History.—The eggs are deposited by the freshly emerged females during the months of May, June and July. The caterpillars upon hatching begin to feed upon the young fruit and foliage and continue their depredations for from forty to sixty days, when they spin their cocoons singly or in large colonies. The moths emerge the same year.

Fig. 412.—Larvæ of the California tussock moth, *Hemerocampa vetusta* (Boisd.). Natural size. (Original)

mate, and the females begin egg-laying. The winter is passed in the egg stage.

Nature of Work.—The caterpillars feed upon the foliage and young fruit, eating entire leaves or portions thereof and irregular holes into the fruit.

²⁹³Mo. Bul. Cal. Hort. Com., Vol. III, p. 657, 1913.

²⁹⁴Volek, W. H., Bul. No. 183, Cal. Agr. Exp. Sta., 1907.

Distribution.—This moth occurs throughout the central and southern parts of the State, especially along the coast.

Food Plants.—The principal cultivated host of this moth is the apple, but it also feeds upon cherry, perennial lupine, manzanita, oaks, black walnut and almond.



Fig. 413.—Adult females of the California tussock moth, *Hemerocampa vetusta* (BoisI.). Slightly enlarged. (Original)

Control.—Spraying with poison sprays has proven unsatisfactory, due to the fact that the caterpillars are able to eat large doses without apparent injury. Hand picking of the egg masses has been followed with considerable success in the Pajaro Valley. This is done during the winter months, after the leaves have fallen. Great care must be exercised in getting all the egg masses to insure profitable results. The eggs should be destroyed by immersing in oil or by burning.

When the caterpillars are on the trees great numbers may be removed by jarring. Bands around the tree trunks, such as are recommended for cankerworms, will keep those jarred off from again ascending the trees. In addition to the cotton and tanglefoot bands, W. H. Volek recommends a rope saturated with tanglefoot, or crude oil rich in asphaltum and tied around the trunks, while bands soaked in a mixture of equal parts of pine tar and molasses have given satisfaction.



Fig. 414.—Cocoons and adult males of the California tussock moth, *Hemerocampa vetusta* (BoisI.). Natural size. (Original)

Steep earth cones around the bases of the trunks may prove satisfactory in keeping the caterpillars from reaching the foliage.

Natural Enemies.—Mr. B. B. Whitney has reared three distinct hymenopterous parasites from the larvæ and pupæ. In addition to these there is the egg parasite (*Telenomus orgyia* Fitch). The tachina fly (*Tachina mella* Walk.) preys upon this species and has been reared in large numbers from the masses of young and pupæ.

THE RUSTY OR ANTIQUE TUSSOCK MOTH

Notolophus antiqua (Linnæus) (Family Lipariidæ)

(*Orgyia nova* Fitch)

(*Phalæna antiqua* Linnæus)

(Fig. 415)

Description.—The caterpillars greatly resemble those of the California tussock moth, but the first two tufts of hairs on the dorsum of the young are black, becoming lighter in the later stages. The female is wingless with the black body covered with yellowish hairs.

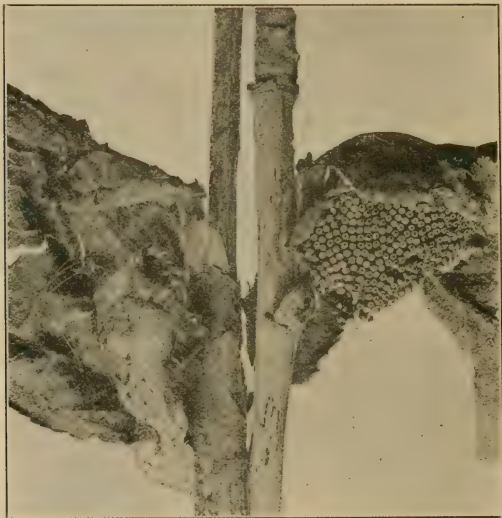


Fig. 415.—Eggs and cocoons of the rusty or antique tussock moth, *Notolophus antiqua* (Linn.), on apple. Slightly enlarged. Specimens taken in Humboldt County by Geo. B. Weatherby. (Original)

The male has reddish-brown wings with two dark-brown bands across and a conspicuous white spot near the rear marginal base of the front pair. The light-colored eggs are laid in large masses on the cocoons, as shown in Fig. 415, and are without protective covering.

Life History.—The life history differs little from that of the California tussock moth. The winter is spent in the egg stage. The eggs

hatch in the spring and the caterpillars feed throughout the summer and adults appear in the fall. There is but a single brood annually.

Distribution.—The eggs of this species have been received from Humboldt County. It does not appear to have been recorded from any other section of the State.

Food Plants.—In this State the apple is the only observed food plant. It also attacks plum and rose, as well as forest and shade trees, especially those belonging to the family *Rosaceæ*.

Control.—Control measures are the same as for the California tussock moth.

Natural Enemies.—This moth is also subject to many of the same natural enemies attacking the California tussock moth.

THE FOREST TENT-CATERPILLAR²⁹⁵

Malacosoma disstria Hübner (Family Lasiocampidae)

(Figs. 416-418)

Description.—The moths are light brown with a dark band across each of the fore wings. The caterpillars are dark with bluish head and a row of diamond-shaped white spots along the middle of the back. They are about 2 inches long. The pupæ are reddish-brown, 1 inch long and inclosed in a light yellow cocoon. All stages of this species in general resemble similar stages of the other tent-caterpillars.

Life History.—The life history is much like that of other caterpillars. The larvæ collect in great colonies upon the trunks and larger limbs of the trees, instead of resting in tents, as does its near relatives.

Nature of Work.—The work of this species is the same as that of the cankerworms.



Fig. 416. — Eggs of the forest tent-caterpillar, *Malacosoma disstria* Hübner, around a small apple twig. Slightly enlarged. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

²⁹⁵Four other tent-caterpillars, which have become of some importance in California are as follows:

1. The California tent-caterpillar, *Malacosoma californica* Packard. The caterpillars are orange-colored and about 1 inch long. They feed normally upon the coast live oak and Maul oak, but also attack apple and other fruit trees.

2. *Malacosoma constricta* Stretch. The caterpillars are somewhat larger than those of the preceding species and may be readily recognized by the distinct blue lines along the sides. They feed upon the black oak and valley oak and have not been reported as pests of fruit trees.

3. *Malacosoma phivialis* Dyer. The caterpillars are buff-colored and usually feed upon the alder, but occasionally become quite injurious to apple trees.

4. The great basin tent-caterpillar, *Malacosoma fragilis* Stretch (Figs. 419, 420). The caterpillars are pale blue on the sides and the median dorsal line is composed of blue spots instead of white spots or a white line as is usually the case in other species. This insect was specially abundant and destructive in the north-central part of the State during the summer of 1914. The caterpillars feed upon *Ceanothus* spp., wild or bitter cherry, wild gooseberry, manzanita, sierra plum, wild rose and willow. (Van Dyke, E. C., Mo. Bul. Cal. Hort. Com., III, pp. 351-355, 1914.)

The apple-tree tent-caterpillar, *Malacosoma americana* (Fab.), though reported from this State, does not seem to have become established and is therefore omitted in this edition.

Distribution.—This caterpillar occurs throughout the central and northern parts of the State.

Food Plants.—The foliage and young fruit of apple, cherry, peach, pear, plum and other fruit trees, as well as the foliage of forest and ornamental trees, are attacked by the forest tent-caterpillar. The oak is the preferred host in the West.



Fig. 417.—Larvæ of the forest tent-caterpillar, *Malacosoma disstria* Hübner, on an apple tree. Greatly reduced. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

Control.—The control of this pest is practically the same as for the tussock moths. Burning is not as efficient for this species as for some of the others. When disturbed most of the caterpillars fall to the ground and may be kept from again reaching the tree by a suitable band around the trunk. Colonies on the trunks are easily and quickly killed by a liberal application of strong whale-oil soap with a large brush. Strong poison sprays are also recommended as soon as the larvæ begin to appear.

Natural Enemy.—*Tachina mella* Walk. has been reared from the pupæ of this species.

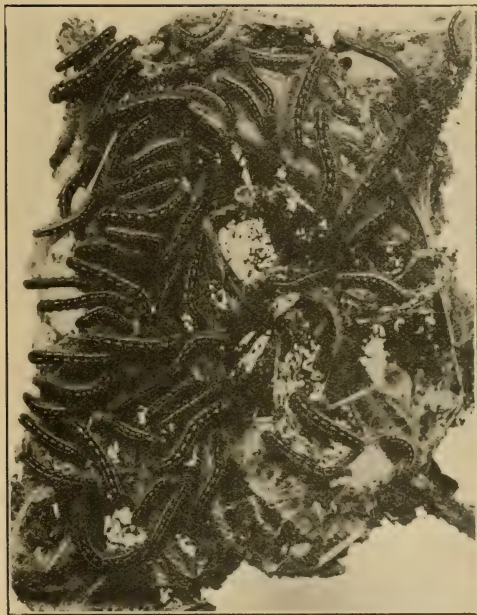


Fig. 418. — Larvæ of the forest tent-caterpillar, *Malacosoma disstria* Hübner, on apple. One fourth natural size. (Original)



Fig. 419.—Nest of the young larvæ of the great basin tent-caterpillar, *Malacosoma fragilis* Stretch, on *Ceanothus*. Slightly reduced. (Original)



Fig. 420.—Female and male of the great basin tent-caterpillar, *Malacosoma fragilis* Stretch. Natural size. Specimens collected at McCloud by Dr. E. C. Van Dyke. (Original)

THE FALL CANKERWORM

Alsophila pometaria (Harris) (Family Geometridæ)
(*Anisopteryx pometaria* Harris)

(Fig. 421)

Description.—In all of its stages this insect greatly resembles the spring cankerworm (*Palcacrita vernata* Peck), but differs in that the larvæ have three pairs of legs on the posterior half of the body, instead of two, and the bodies are more distinctly striped. They average about 1 inch in length. The primary wings of the males also have an extra light band near the middle. The females are gray and wingless. The eggs are shaped like small flower pots, being smaller at the bottom and with distinct darker circles at the top. They are deposited in regular clusters of from fifty to two hundred, standing side by side in exposed places.

Life History.—The life history is practically the same as that of the spring cankerworm, but the

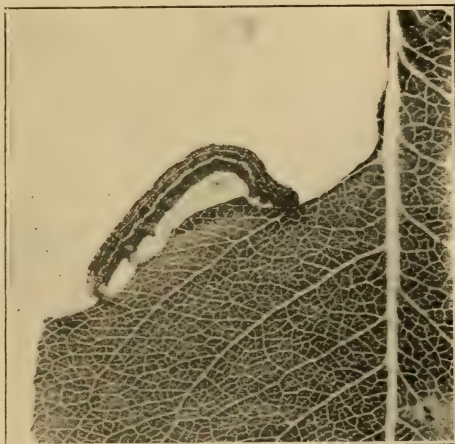


Fig. 421.—The fall cankerworm, *Alsophila pometaria* (Harris). Larva in characteristic feeding attitude on apricot leaf. Enlarged twice. (Original)

eggs are deposited in a compact mass and glued to the twigs and covered with hairs from the female's body, in the late fall or during the milder portions of winter, as late as March. The young hatch about the same time as those of the spring forms and work about the same. Full-grown larvæ were received from Vacaville, April 4, 1914, but they were accompanied by many very small ones. The adults issue from October to December, or as late as spring, and immediately crawl up the trunks to deposit their eggs.

Nature of Work.—The work of this species is the same as that of the spring cankerworm.

Distribution.—This insect is found in the central and northern parts of the State.

Food Plants.—The fruit and foliage of the apple, apricot, cherry, elm, maple, plum, prune and other fruit trees. The foliage of many forest and ornamental trees are attacked.

Control.—Control measures as recommended for the spring cankerworm may be used for this species. Bands around the tree trunks will not prove as effectual, because of heavy winter rains, unless they are

occasionally renewed. These barriers must be put in place during September and October and continued until spring.

Spray with arsenate of lead, 2 pounds to 50 gallons of water, just before the blossoms open, and again in one week.

Natural Enemies.— This species is subject to the same natural enemies as is the spring cankerworm.

THE SPRING CANKERWORM

Paleacrita vernata (Peck) (Family Geometridæ)

[*Anisopterix vernata* (Peck)]

(*Phalana vernata* Peck)

(Figs. 422, 423)

Description.— The larvæ are dark olive-green, brown or nearly black, very slender and about 1 inch long. Because of their looping method of traveling they are often called measuring worms. In this species they possess but two pairs of legs on the under side of the



Fig. 422. — Apricot branch showing the work of the larvæ of the spring cankerworm on fruit and foliage. (After Craw, Cal. Hort. Com.)



Fig. 423. — Larva of the spring cankerworm, *Paleacrita vernata* (Peck), on pear leaf. Slightly enlarged. (Original)

posterior half of the body. The cocoon is composed of tough silken web, which is not easily broken. The pupa is grayish-brown. The female is wingless and covered with soft gray down. The male is winged and gray in color. The eggs are regularly oval.

Life History.—The female of the spring cankerworm oviposits in the spring, before the buds of the apple trees start. The eggs are laid singly or in irregular masses in crevices or under the bark scales on the limbs, trunks, twigs or leaves. The young cankerworms hatch out just in time to begin destroying the first young leaves. They often occur in such numbers as to almost entirely defoliate the trees and cause great loss. After they mature they drop to the ground and pupate in a cocoon, just beneath the surface, where they hibernate through the winter, and the adults appear early the next spring. There is but one generation each year. The females, not having wings, must crawl up the tree trunks in the spring to deposit their eggs in suitable places during March and April.

Nature of Work.—The larvæ eat ragged holes into the leaves or entirely strip the leaves from the trees and gnaw holes into the young fruit (Fig. 422).

Distribution.—This species occurs throughout the apple-growing sections of the central and northern parts of the State.

Food Plants.—Among the many plants attacked are: apple, apricot, cherry, elm, maple, pear, plum and prune.

Control.—Inasmuch as the female is wingless, the spread of this pest is not very rapid and control is not so difficult as is the case with many of the orchard caterpillars. The female must crawl up the tree trunk in the early spring to oviposit, and any methods adopted to prevent this will reduce subsequent injury by the larvæ. Bands of adhesive paper or cotton around the trunks have proven effective, while one of tree tanglefoot, about two inches wide, has been very satisfactory. Any of these devices will cause the females to oviposit below the bands and the young can be easily and readily killed with a soap wash. The bands should be in place about the first of March.

In cases where the young caterpillars are already on the trees, or where the above methods have not kept them from the foliage, arsenical sprays should be applied while the caterpillars are still small, as early defoliation is always serious.

Plowing and harrowing close to the trees in the fall and winter is said to crush numbers of the pupæ in the cocoons in the soil and aid in reducing the next spring's broods.

Natural Enemies.—The eggs are parasitized by chalcid flies and preyed upon by mites, while birds, ichneumonid parasites, tachina flies and predaceous beetles prey upon the larvæ.

THE OMNIVOROUS LOOPER

Sabulodes caberata Gueneé (Family Geometridæ)

(*Tetracis agrotata* Gueneé)

(Figs. 424-428)

Description.—The adult is a beautiful, delicate, terra-cotta-colored moth with nearly or pure white ventral surface. Each of the wings has two irregular dusky transverse bands on the upper surface, one on each side of the middle. The margin, near the middle, is extended in a blunt projection. The under surface is creamy-white, peppered with many small dark spots. The abdomen is also sparsely covered with

similar minute black specks. The eyes are black. The body averages $\frac{3}{4}$ inch in length and the wing expanse is about 2 inches. The eggs are greenish, shiny amber or pinkish-brown, nearly globular. The diameter is about $\frac{1}{32}$ inch. They are laid singly or in small, loose clusters of two or more. The full-grown caterpillar is light green and yellow with often a decided pinkish color. There are alternating longitudinal stripes of yellow and green on the sides and back and many black markings over the body. There are also fine black lines on the back and a distinct larger black line on each side. There are occasionally black spots on the legs, at the posterior end of the body and on the head. Fig. 425 shows the general appearance. The

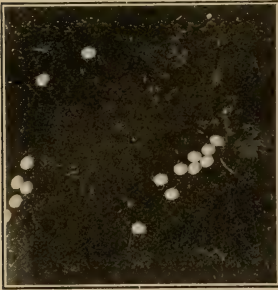


Fig. 424.—Eggs of the omnivorous looper, *Psephenoplacidia* (Guen.). Enlarged four times. (Original)

length varies from $1\frac{1}{2}$ to $1\frac{3}{4}$ inches. The larva spins a web in a fold of a leaf or between two or more leaves, which it fastens securely together. In this web it rests during the day and retreats to it if disturbed. In the web also, which is later reinforced to form a thin white cocoon, pupation takes place. The pupa is first almost white, but the developing wing pads soon turn to a beautiful chestnut brown and there may also appear a few dark spots near the posterior end. The eyes are also brown, or nearly black. The average length of the pupa is $\frac{3}{4}$ inch.

Life History. — The winter is passed in the young larval, adult and the egg stage. The larvæ appear in the spring and the first brood matures by summer. The last brood matures in late September and in October and the adults begin egg-laying during the latter month. The larvæ are peculiar, in that they spin a web in which they rest during the day and leave to feed during the night, though they also may be found feeding on dull cloudy days.



Fig. 425.—Larvæ of the omnivorous looper, *Sabulodes caberata* Guen. Enlarged twice. (Original)

It requires about one month for the larvæ to become full-grown and half as long for the pupal stage. There are several uneven broods a year. The last brood in the late fall appears to be the largest and most injurious.

Nature of Work.—The larvæ fold the leaves to build their webs and devour all of the tender foliage, often completely defoliating the plants.

Distribution.—This moth appears to be generally distributed throughout the State. It is specially abundant in the San Francisco Bay region, and was also reported as doing some damage in Ventura County.

Food Plants.—The larvæ of this moth feed upon a large number of plants, seemingly devouring everything at hand. So far the list is only partial, but gives some idea of the wide variety.



Fig. 426.—Rolled leaves showing larval nests and cocoons of the omnivorous looper, *Sabulodes caberata* Guen. Natural size. (Original)

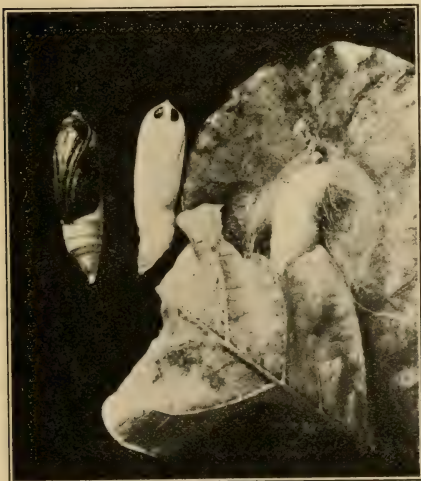


Fig. 427.—The omnivorous looper, *Sabulodes caberata* Guen. Two pupæ removed from the cocoons and a pupa within the cocoon on the folded leaves. Slightly enlarged. (Original)

At Berkeley, Miss Mary Ames and Dr. E. C. Van Dyke report the following food plants: alder, cherry, groundsel, pepper tree, rose, sumach and lemon verbena. To this list Mr. E. P. Van Duzee adds geranium (apparently all species) and English ivy. Miss Dorris Hutchins reports maple, California laurel and passion vine. Mr. I. P. Condit has taken the larvæ feeding upon lemon trees. Mr. C. J. Pierson reports acacia, box-elder, buckeye, chestnut, elm, eucalyptus, grevillea, magnolia, mountain holly, sycamore, black walnut and willow. The writer has noted elematis, Shasta daisy, honeysuckle, orange, olive and violet. S. H. Essig collected larvæ at Ventura

feeding upon the trumpet vine. Undoubtedly a much larger number of plants are also attacked.

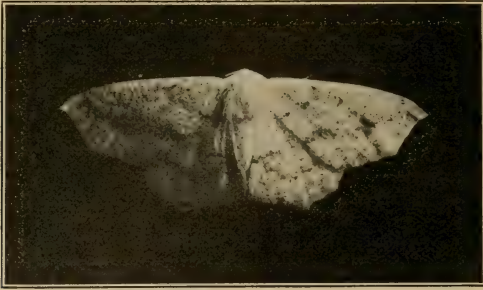


Fig. 428.—Adult female of the omnivorous looper, *Sabu-loas cubeyata* Guen., in natural resting attitude. The photo is of a living moth. Slightly enlarged. (Original)

Control.—Ordinarily the attack of this moth is not serious enough to warrant control measures. However, in case remedies are thought necessary, the application of arsenical dusts and sprays will prove effective.

THE PEACH TREE BORER

Egeria critiosa Say (Family *Egeriidae*)²⁹⁶

[*Sanninoidea critiosa* (Say)]

(Fig. 429)

Description.—The adults are known as clear-winged moths because of the lack of color-scales on some parts of the transparent membrane between the veins of the wings. The wings are rather long and slender, as are also the bodies, which cause them to be frequently mistaken for large wasps. The females are iridescent steel-blue with purple or greenish reflections. There is a broad orange-colored band across the middle of the abdomen. The fore wings are entirely covered with scales and are opaque, while the hind wings are perfectly transparent excepting the veins. The body is about $\frac{3}{4}$ inch long and the wing expanse averages $1\frac{1}{2}$ inches. The males are considerably smaller, of the same steel-blue color, but lack the orange-colored band across the abdomen and instead have bright yellow markings on the head, thorax and legs, two slender bands on the abdomen, two light-colored and a black tuft at the end of the abdomen. The wings are transparent, excepting a small blue patch across the middle of the front pair. The eggs are oval or slightly flattened, dull yellow with finely sculptured surface and $\frac{1}{30}$ inch long. The full-grown larvæ or caterpillars are pale yellowish with brown head and black mouth parts. There are three pairs of true legs and five pairs of prolegs. The average length is from 1 to $1\frac{1}{2}$ inches. The cocoons are made of frass, gum and silk and are very stiff pod-like structures. In these the reddish-brown pupæ are usually to be found near the entrance of the old burrows, near the surface of the soil or

²⁹⁶According to Mr. August Busck, the genera *Sanninoidea* and *Sesia* have been dropped as synonyms of *Egeria*. The family name, *Egeriidae*, also replaces *Sesiidae*.

among the roots just under the surface. The pupæ, when fully matured, wriggle out of the burrows and protrude nearly the whole length before the adults escape, leaving the skins in this characteristic position.

Life History.—The winter is spent in the larval stage in the old burrows under the bark or in small new hibernaculæ in the bark made by the smaller caterpillars. Work is probably continued throughout the winter where the insect occurs in this State, as all sizes of the larvæ may be found. When full-grown the larvæ leave their burrows and construct cocoons near the burrows or roots. The pupal period lasts from three to four weeks, when the adults emerge. These soon mate and the females deposit their eggs on the trunks of the trees or upon the adjacent weeds or ground. From two



Fig. 429.—The peach tree borer, *Egeria exitiosa* Say. Adult female at top and males at bottom. Slightly enlarged. Specimens reared from pupæ collected in San Diego County by H. A. Weinland. (Original)

hundred to eight hundred eggs are laid by a single female. These hatch in eight or ten days, and the larvæ make their burrows into the bark of the tree through cracks or crevices. Growth is rapid during the summer, so that many are practically full-grown by winter, when the hibernation begins. There is but one brood a year.

Nature of Work.—The work of this species is practically the same as that of the California peach borer.

Distribution.—Though this species has often been taken in quarantine on nursery stock, it was not known to exist in the State until it was discovered at Dehesa, in San Diego County, by H. A. Weinland, County Horticultural Commissioner, in the spring of 1914. Specimens of larvæ and pupæ were received by the writer and adults reared, so there is no question concerning the identity of the species.

Food Plants.—The peach appears to be the favorite food plant, though any of the stone fruits, including apricot, cherry, nectarine, plum and prune, are also frequently attacked. The wild cherry and wild plum and certain ornamental shrubs are also host plants.

Control.—The treatments are the same as for the California peach borer.

Natural Enemies.—In the Eastern States a small parasite (*Telenomus quaintancei* Girault)²⁹⁷ destroys as many as fifty per cent of the eggs. The parasite probably does not occur in California.

²⁹⁷Quaintance, A. L., Yearbook, U. S. Dept. Agric., p. 333, 1905.

THE CALIFORNIA PEACH BORER

Egeria opalescens H. Edwards (Family *Ægeriidae*)²⁹⁶
[*Sanninoidra opalescens* (H. Edwards)]

(Figs. 430-432)

Description.—The moths are nearly 1 inch in length with a somewhat greater wing expanse. They greatly resemble wasps in coloration and shape, the clear areas in the wings adding to the deception. The color is steel-blue, the fringes of the wings and appendages are jet black, the legs fringed with white tufts. The females have a bronzy

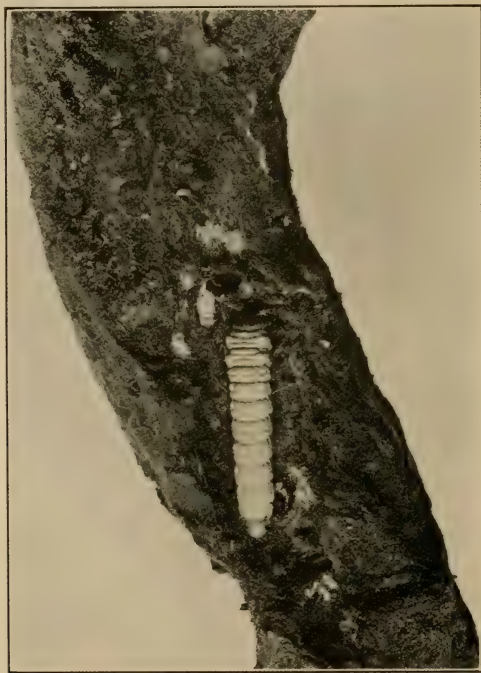


Fig. 430.—Larva of the California peach borer, *Egeria opalescens* H. Edw., and work on a young peach tree. Natural size. (Original)

hue with the fore wings entirely covered with dark scales. The dark-brown eggs are depressed on the sides and one end. The full-grown larvæ are white or dusky in color with brown heads and attain a length of from 1 to 1½ inches. The pupæ are light brown and are found in the bark or around the bases of the trees.

Life History.—The eggs are always laid on the lower part of the trunks of the trees, a few inches above the surface of the soil. They

are arranged singly or in small groups of from three to fifteen. Each moth lays from two hundred to over four hundred eggs, and it requires from fifteen to thirty days for them to hatch. The newly hatched larvæ immediately seek shelter in cracks or crevices of the bark or beneath the ground and at once begin to enter the trunk of the tree by boring with great rapidity through the bark, or in infested orchards they enter the old burrows. During the summer the young work upon the growing inner bark, burrowing downward or upward at will. The burrows are usually made under the surface of the ground, but occasionally they are extended quite far up the trunks. This is especially true on the silver prune. The frass and gum are forced out of exit holes through the sides of the trees, thus greatly facilitating the location of the burrows. The larvæ remain in the burrows during the winter months and continue fairly active. About January and February they begin to transform into pupæ. These remain in the old burrows for about one and one half months, when the adults emerge in the spring and mate to begin egg-laying. There is but one generation a year.

Nature of Work.—The caterpillars usually work around the crown of the tree, just under the bark, near the surface of the ground, though their burrows may extend quite far up the trunk. The work after successive seasons usually serves to entirely girdle and kill the tree in time. The exuding gum and rejected frass from the entrance of the burrows are evidences of the presence of the larvæ, in addition to the unhealthy appearance of the tree which accompanies the attacks.

Distribution.—The distribution of the peach borer is wider than was first realized. Adults have often been taken by collectors in the mountains, especially the Sierra Nevadas, but the distribution in the



Fig. 431.—The California peach borer, *Egeria opalescens* H. Edw. Cocoons and pupal skins at top; male and female moths at the bottom. Natural size. (Original)

valleys where damage to fruit trees has been done was thought to be limited to Alameda, San Benito, Santa Cruz, Monterey and San Mateo counties and the Santa Clara Valley. During the past two years it has also been discovered in the vicinity of Banning, Riverside County, and in the Upper Ojai Valley, Ventura County.

Food Plants.—This insect is limited, as a pest, to a very small area of the State and is much dreaded because of the character of its work and the great damage it does to the infested trees. Though principally a peach tree borer, it works almost equally as destructively upon almonds, apricots, prunes, cherries, plums and western chokecherry (*Cerasus demissa*). Apple stock is attacked to some degree also.

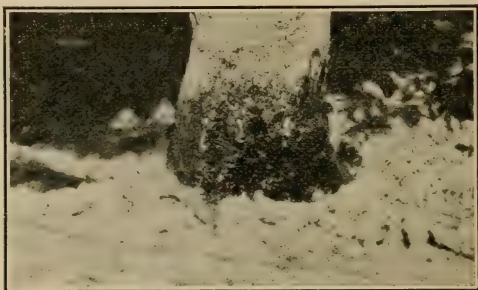


Fig. 432.—Asphaltum around the base of a peach tree to prevent the entrance of the young larvæ of the California peach borer. (After Morris, Cal. Agrcl. Exp. Sta.)

Control.—Trees budded or grafted upon stocks of any of the host plants are most likely to become infested, while it has been found that the borer will not injure trees grafted upon the Myrobalan plum (*Prunus cerasifera*). The use of this stock is becoming a sure means of controlling the pest in the future.

Protective washes of lime-crude oil mixture, lime-sulphur-salt mixture, or lime, coal tar, and whale-oil soap are recommended by Dudley Moulton as sprays to be applied before the middle of June. Digging out the worms or killing them with a crooked wire should be practiced in the fall, winter and spring months.

Earl Morris,²⁹⁸ Horticultural Commissioner of Santa Clara County, has invented a method of control that appears to be better than anything else yet tried. His method consists in applying grades "C" and "D" of hard asphaltum. This is done early in the spring to infested trees, and a heavy coating prevents both the issuance and entrance of from ninety-five to ninety-eight per cent of the insects. The material, boiling hot, is applied from five to six inches below and above the surface of the soil with a brush. Two coatings are recommended. This method should follow fall and spring digging for the borers.

²⁹⁸Bul. No. 228, Cal. Agrcl. Exp. Sta., pp. 372-374, 1912.

THE STRAWBERRY CROWN MOTH

Egeria rutilans (H. Edwards) (Family *Ageriidae*)²⁹⁶[*Sesia rutilans* (H. Edwards)](*Synanthedon rutilans* H. Edwards)

(Figs. 433, 434)

Description.—The adults are clear-winged moths, the females having a wing expanse of about $\frac{3}{4}$ inch, the males being somewhat smaller. The ground color of the body is black with oblique longitudinal stripes on the thorax and yellow bands around the abdomen. The antennæ are bluish black and the legs yellow with black rings. The fore wings are almost entirely covered with brown and black scales, having a purple iridescence. There are yellow stripes between the veins and the outer border is brown and yellow. The hind wings are nearly all transparent with brown border. The tuft at the tip of the abdomen is yellow and black. The males are much darker than the females, having fewer and narrower yellow bands on the body and the anal tuft is larger and all black. The larvæ are cylindrical, white with reddish-brown head, black legs and mandibles, covered with brownish hair and slightly over $\frac{1}{2}$ inch long. The pupæ are enclosed in brownish cocoons, the chrysalids being reddish-brown with several rows of dark spines across the back and sides. They are about $\frac{1}{2}$ inch long and are usually found within the old larval burrows.

Life History.—The moths begin to issue about April, continuing to appear until the latter part of July. The eggs are laid soon after the adults appear and the young larvæ hatch in the summer or fall and work during the winter and spring, most of the damage being done in the spring, about February. Soon after this pupation begins, so that adults may begin to issue in April. The brood is uneven, for pupæ may be found as late as June.

Nature of Work.—The larvæ work in the crown of the plants, eventually killing them. Fig. 434 shows the nature of their attacks.

Distribution.—This moth is distributed throughout the central and southern parts of the State, though specimens may occur quite far north in the Sacramento Valley.

Food Plants.—The larvæ work within the stems near the base or in the roots near the crown of the host plants. They are exceedingly destructive to strawberry plants, working within the crowns and roots. They also feed within the roots and canes of raspberry and blackberry plants. Their presence usually means the complete destruction of the plants unless control measures are promptly adopted. Mr. H. H. Bowman, Horticultural Commissioner of Placer County, who has rendered



Fig. 433. — Adult female of the strawberry crown moth, *Egeria rutilans* (H. Edw.). Enlarged twice. Specimen collected at Bowman by H. H. Bowman. (Original)

valuable aid to the writer in studying this insect, estimates the annual loss to be from one-tenth to one-fifth of the vines in many sections of Placer County.



FIG. 434.—The strawberry crown moth, *Egeria rutilans* (H. Edw.). Larvæ and their work in the crown of a strawberry plant. Enlarged twice. Specimens taken at Bowman by H. H. Bowman. (Original)

Control.—Submersion, when possible, is a quick and thorough means of exterminating the pest, but of course this is limited to irrigated districts. The fields should be flooded soon after the crop is harvested and the water left standing over the vines for four or five days. The destruction of weakened and infested plants is also recommended to prevent the spread of the moth. Valuable plants can be protected with screens or netting to prevent the moths depositing their eggs upon them.

THE IMPORTED CURRANT BORER

Egeria tipuliformis Clerck (Family *Ægeriidae*)²⁰⁰[*Sesia tipuliformis* (Clerck)]

(Figs. 435, 436)

Description.—The adult females are clear-winged moths with delicate, slender bodies about $\frac{3}{8}$ inch long and a wing expanse of from $\frac{5}{8}$ to $\frac{3}{4}$ inch. The general color is jet black with deep blue iridescence. There is a yellow band around the base of the head, three distinct and two indistinct yellow bands around the abdomen and two oblique longitudinal yellow stripes on the thorax. Because of sunshine these lines and bands are misleading in the photograph (Fig. 435), excepting the last two abdominal rings in the left-hand specimen. The areas on the thorax just below the wings are also yellow. The front wings are

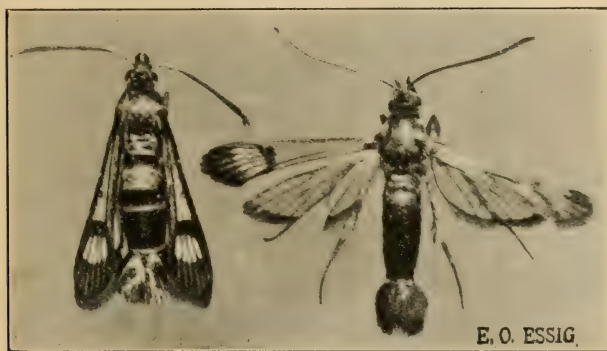


Fig. 435.—Adults of the imported currant borer, *Egeria tipuliformis* Clerck. Enlarged twice. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

opaque along the borders, with a small band inclosing a clear area near the opaque tips, which are bronze. The hind wings are clear, excepting a brown border. The legs are banded yellow and black with the inner sides of tibiae and tarsi yellow and the outer sides black. The larvæ are slightly more than $\frac{1}{2}$ inch in length and yellowish white, with dark heads. The chrysalids are amber brown. The eggs are globular and light brown.

Life History.—The eggs are laid singly in May and June upon the canes, near the buds, of currant and gooseberry, on wood less than one year old. From twenty to sixty are laid by each female. They hatch very quickly, and the larvæ at once bore into the cane and work upon the inner pith during the summer and fall. By winter the burrows extend, many of them to the roots, where most of the larvæ hibernate during the winter. In the spring pupation takes place within the burrows, lasting from two to three weeks, and the adults emerge in May and June, by means of holes cut through the sides of the stems. They may be found about the plants during the hottest part of the day.

Nature of Work.—The larvæ make their burrows down the pith of the stems, which are eventually killed. The dead twigs, the tunnels filled with frass and the exit holes of the adults are characteristic signs of the presence of this pest.

Distribution.—The imported currant borer is limited to the northern and central parts of the State, and more particularly to the Sierra foothill regions.

Food Plants.—The young caterpillars work on the pith within the stalks or canes of the currant and gooseberry, doing much damage to the fruit-bearing wood. In not a few cases entire patches have been



Fig. 436.—Pupal skins of the imported currant borer, *Egeria tipuliformis* Clerck, at the exit holes of the burrows. Enlarged twice. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

rendered worthless before the unsuspecting grower was aware of the real cause of the dying bushes. Currant, black elder, red and black gooseberry, hazelnut and sumach are recorded as hosts in Europe.²⁰⁰

Control.—Control is rather difficult and consists in cutting out and burning the sickly-looking canes as often as they appear. The best time to do this work is in the spring. If living canes are infested, the larvæ may sometimes be killed by thrusting a wire down the burrow.

²⁰⁰Rev. Appld. Ent. I, p. 68, 1913.

THE SQUASH-VINE BORER²⁰⁰*Melittia satyriniformis* Hübner (Family Tegeriidae)²⁰⁰(*Trochilium ceto* Westwood)(*Melittia cucurbita* Harris)(*Melittia pulchripes* Walker)(*Melittia amana* H. Edwards)

(Fig. 437)

Description.—The adults are beautiful clear-winged moths. The head and thorax are dark, the abdomen is marked with orange or red and black or bronze; the fore wings are opaque, olive-brown with green iridescence; the hind wings are transparent with black veins and olive green or bronze fringe of hairs. The hind legs bear a large fringe of hairs which is orange on the outer side and black on the inside. These hairs are longer on the male than on the female. The wing expanse of the females is about $1\frac{1}{2}$ inches and $1\frac{1}{4}$ inches or less for the males. The eggs are reddish-brown, oval, about $\frac{1}{25}$ inch long and attached at the side. The larvæ or borers are white with dark brown head, robust, distinctly segmented and 1 inch long. The pupæ are shiny, dark red or brownish, with horn or spine on head, many spines on abdomen and $\frac{2}{3}$ inch long. They are inclosed in dark closely woven cocoons covered with small soil particles from the resting place in the earth.

Life History.—

The winter is passed in the pupal stage in the soil. Adults begin to emerge in April and May and to lay eggs upon the larger stems near the ground and all other parts of the food plants. A single female may deposit several hundred eggs. The eggs hatch in about two weeks and the larvæ at once make burrows into the stems, some working down into the roots while others burrow into the base and woody parts of the plants. White frass is forced from the tunnels by the feeding larvæ. It requires about one month for the larvæ to become full-grown. They then leave the plants and enter the soil near the bases to a depth of about two inches, where the pupal cells are made, the cocoon constructed and pupation takes place. In from two to three weeks the adults begin to emerge. The entire life cycle requires about two months. The adults of the first generation appear in June and July and those of the second generation in August and September. There are two broods a year.

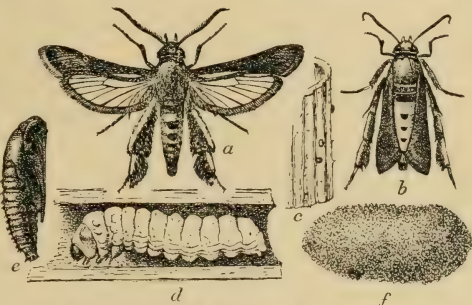


Fig. 437.—The squash-vine borer, *Melittia satyriniformis* Hüb. a, adult male; b, adult female; c, eggs on stem; d, full-grown larva in stem; e, pupa; f, cocoon. Enlarged one and one third times. (After Chittenden, U. S. Dept. Agric.)

²⁰⁰Smith, John B., Bul. No. 94, N. J. Agrcl. Exp. Sta., 1893.
Chittenden, F. H., Circ. No. 38, Bur. Ent. U. S. Dept. Agric., 1908.
Smith, R. L., Bul. 205, N. C. Agrcl. Exp. Sta., 1910.

Nature of Work.—Burrows are made in the middle of the stems and leaf stalks, which are occasionally cut off, causing the leaves to wilt and the plants to die. Many larvæ may inhabit a single plant, so the signs of their work are sometimes very sudden. The white frass at the entrance of the burrows is an indication of the presence of the borer. Late crops are injured most. Gourds are often burrowed into.

Distribution.—Prof. C. W. Woodworth³⁰¹ records this as a California insect. Its distribution within the State is evidently limited. It occurs in the United States, Canada, Mexico, Guatemala, Panama, Brazil and Argentine Republic, as recorded by Dr. Dyar.

Food Plants.³⁰²—Cantaloupes, cucumber, wild balsam apple (*Echinocystis lobata*), gourd, muskmelon, pumpkin, squash and watermelon. The late varieties of squashes (Hubbard, marrow, cymlings, etc.) are injured most.

Control.—Planting early trap crops of summer squash and other early varieties between the rows of the later varieties and burning these to destroy larvæ and eggs will greatly reduce infestation of the main crops. Plantings in July are not usually severely attacked. It is also advisable to kill adult moths which are sluggish and easily captured late in the evening. They are usually to be found upon the upper surface of the leaves. All vines should be burned in the fall, as early as possible, to destroy any of the larvæ which have not gone into the ground to pass the winter. Deep fall and spring plowing will bury the over-wintering pupæ, so that the adults can not make their way out in the spring. Burying the vines at the nodes, so that roots will be sent out to support the shoots in case the main stalks are injured at the base, is also recommended. If only a small patch is infested the vines may be saved by digging out the borers, avoiding planting on or near infested soil.

THE MELON WORM³⁰³

Diaphania hyalinata (Linnæus) (Family Pyralidæ)

[*Glyphodes hyalinata* (Linnæus)]

(*Phalana hyalinata* Linnæus)

(Fig. 438)

Description.—The moths are beautiful, pearly-white with the front margin and borders of the wings, tuft at the tip of the abdomen, the head, anterior half of the thorax and ventral surface a rich brown. The wing expanse is about 1 inch, the length of the body $\frac{1}{2}$ inch. The eggs are small, pearly-white and laid in masses of from two to six. The larvæ or caterpillars are pale yellow with brown head and two white longitudinal stripes down the back. When full-grown they are about $1\frac{1}{4}$ inches long. The pupæ are rich brown in color and about $\frac{3}{4}$ inch long. They are enclosed in thin white cocoons spun in the folded edges of the green leaves.

Life History.—The winter is passed in the pupal stages, usually upon the old vines or in rubbish or protected places about the fields. Adults begin to emerge in May, June and July and lay their eggs

³⁰¹Cal. Insects, p. 62, 1913.

³⁰²Chittenden, F. H., Cir. No. 38, Bur. Ent. U. S. Dept. Agric., pp. 2-3, 1908.

³⁰³Smith, R. I., Bul. No. 206, N. C. Agrcl. Exp. Sta., 1910, and Bul. No. 214, N. C. Agrcl. Exp. Sta., 1911

chiefly upon the tender young leaves, but also upon the stems and older leaves. The eggs hatch in about four days and the larvæ mature in about two weeks. When feeding, which is done mostly at night, the



Fig. 438.—Adult female of the melon worm, *Diaphania hyalinata* (Linn.). Enlarged three times. Specimen received from Prof. R. I. Smith, West Raleigh, N. C. (Original)

caterpillars protect themselves by a thin web. When ready to pupate they spin a white silken cocoon. The pupal stage lasts a little over a week. The entire life cycle requires about one month. There are three or four generations a year.

Nature of Work.—The caterpillars destroy the foliage by eating holes into the leaves or devouring them entirely. The young buds and unfolding leaves are favorite portions of the plants, especially of the young. They also eat holes into the young melons, cucumbers, etc., thus destroying them for market purposes.

Distribution.—The writer has been unable to find any records of damage done in California by this pest. Professor C. W. Woodworth records it as occurring in the State.³⁰⁴

Food Plants.—Cushaw, cucumber, gourd, muskmelon, squash and watermelon are commonly attacked by the melon worm.

Control.—An important thing in the control of this pest is the destruction of the vines, weeds and other rubbish in the fields by burning in the fall and winter to kill the hibernating pupæ. Deep fall plowing also kills many of these. Planting early trap crops and spraying them heavily with neutral lead arsenate (4 pounds to 50 gallons of water), or Paris green (1½ pounds to 50 gallons of water), will destroy great numbers of the first broods. The cultivated crops should be sprayed with lead arsenate paste, 3 pounds to 50 gallons of water, lead arsenate powder, 1½ pounds to 50 gallons of water, or a mixture of ½ pound of Paris green and 1 pound of slaked lime to 50 gallons of water.³⁰⁵ In California the melon worm has not become a serious pest and control measures so far have been unnecessary.

³⁰⁴Cal. Insects, p. 64, 1913.

³⁰⁵Watson, J. R., Press Bul. No. 209, Fla. Agrcl. Exp. Sta., p. 2, 1913.

THE GRAPE LEAF-FOLDER

Desmia funeralis Hübner (Family Pyralidæ)(*Desmia maculalis* Westwood)

Description.—The full-grown caterpillars are light green with a dark brown head and a brown spot on each side of the first two segments. The length averages 1 inch. The pupæ are inclosed in thin silken cocoons in the leaf rolls, are light brown and $\frac{1}{2}$ inch long. The moths are dark brown or black with a bluish iridescence. The females have two white bands across the bodies and two white spots and a white border on each of the fore wings. The bodies of the males have but one transverse white band, white wing borders, two white spots on each of the front wings and a single large white spot on each hind wing. The tarsi and apical halves of the antennæ of both sexes are white. The length averages nearly $\frac{3}{4}$ inch.

Life History.³⁰⁶—The winter is spent in the pupal stage within the leaf rolls upon the ground. The adults appear in April and May and deposit the eggs singly or in groups upon the leaves. The larvæ begin to appear about the first of June and soon fold the edges of the leaves to one third or one half the distance across into a compact roll about the size of a lead pencil. In these retreats the larvæ live and feed upon the edges of the leaves. The first brood is comparatively small and little damage is done in the early part of the season. The caterpillars of this brood are mature by about the first of July, when they pupate and the adults emerge in a week or ten days and lay eggs which hatch into a larger second brood. This second brood usually does the most damage, though it is not at all serious. The pupæ of the second brood remain in the rolls after the leaves have dropped and do not transform into adults until the following spring. There are but two broods a year.

Nature of Work.—The edges of the leaves are tightly rolled by the larvæ into a retreat about as large as a lead pencil. The rolls are always on the undersides of the leaves and one or several may be made on a leaf. The caterpillars feed upon the edges of the leaves and occasionally upon the young berries and blossoms, but in California have never been present in sufficient numbers to do much damage.

Distribution.—The grape leaf-folder occurs in the central part of the State, being most abundant in the Sacramento and San Joaquin Valleys.

Food Plant.—The grape is the only recorded food plant of this insect.

Control.—The grape leaf-folder has never been a pest in California and control measures have been unnecessary. However, if any serious damage is done, an arsenical spray would be sufficient to protect the crop if applied early.

³⁰⁶Quayle, H. J., Bul. No. 192, Cal. Agrcl. Exp. Sta., pp. 129-137, 1907.

THE LIMA BEAN POD-BORER

Etiella zinckenella (Treitschke) (Family Pyralidæ)*(Phycis zinckenella Trietschke)*

(Fig. 439)

Description.—The adult moth is gray with ocherous blotches on the fore wings. There is a plain, broad, white band along the margins of these wings and an ocherous band with brown spots across the inner fourth. This band is especially conspicuous. The hind wings are light gray. The moth is small, scarcely more than $\frac{1}{2}$ inch long. It is exceedingly active on wing and foot. The pupa is rich brown and usually



Fig. 439.—Lima beans showing the work of the larvæ of the lima bean pod-borer, *Etiella zinckenella* (Treit.). Enlarged twice. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

inclosed in a thin white cocoon. The young larva is white or light green. When full-grown it is white or distinctly reddish above and greenish beneath. The head is dark, as is also the prothoracic plate and the legs. It averages about 1 inch in length. When disturbed it wriggles violently.

Life History.—The writer has never seen the eggs, so is unable to state where they are deposited, but judging from the observance of the work of this insect they are probably laid upon the bean plants and the pods as soon as they are formed. Upon hatching, the young caterpillars bore through the pods and begin feeding upon the beans inside, all of which are usually gnawed into or destroyed before fully

developed. Pupation takes place within the pods, under clods or any other convenient shelter. As a protection, a thin white cocoon is spun. In this stage some of the insects hibernate, though many appear as adults in late summer and fall. There is but one brood a year. The adults appear in the spring, about May.

Nature of Work.—The larvæ bore through the pods and eat the growing beans inside, as shown in Fig. 439.

Distribution.—Most of the records concerning this pest have come from the southern part of the State, where it is apparently well established. As early as 1885 Albert Kæbele collected it in El Dorado County, so it probably occurs in limited numbers in the central part as well. The moth is believed to be of European or Asiatic origin, having been imported into this country.

Food Plants.—The growing beans in the pods of the bush-limas are preferred, though occasionally other varieties of lima beans and the pods of lupines are attacked.

Control.—Early beans are the ones suffering most from the attacks of the caterpillars, though the later plantings do not escape. As the bush-lima is usually the only crop attacked it would be well to plant the large and later varieties instead.

THE BEE MOTH

Galleria mellonella (Linnaeus) (Family Pyralidae)

(*Phalena mellonella* Linnaeus)

(Figs. 440, 441)

Description.—The adult moths are from $\frac{5}{8}$ to $\frac{7}{8}$ inch long with a wing expanse of from $1\frac{1}{4}$ to $1\frac{3}{4}$ inches. The general color is gray, though the anterior halves of the front wings which rest against the sides of the body are dull lead color while the remainder which covers the dorsum is light with distinct black markings. The hind wings are yellowish-gray with dark tips. The body, legs and antennæ are silvery-gray. The males are smaller than the females and are easily recognized by a scallop on the outer margin of the fore wings and the absence of palpi.³⁰⁷ The eggs are elliptical, pearly-white and about $\frac{1}{16}$ inch long. The larvæ, when first hatched, are white and when fully matured vary from white to light dirty yellow with brown or black head and prothoracic shield. In some individuals there are black markings upon the dorsum, as shown in Fig. 440. The cocoon varies from 1 to $1\frac{1}{4}$ inches in length, is white in color and though spun of fine silk is very tough, stiff and bee proof. The pupa is rich brown in color and varies from $\frac{1}{2}$ to $\frac{3}{8}$ inch in length.

Life History.—The eggs are laid on or near the comb and hatch within ten or twelve days. There are usually about three overlapping broods a year. The winter is spent in the larval and pupal stages within the cocoons. The adults begin to emerge in the spring, in April and May, and soon begin egg-laying. The eggs of the first brood are laid from about the middle of April to the middle of May, those of the second brood from the middle of July to the middle of August, and of the third brood from the last of September to the first of November. Larvæ and pupæ of the second and third broods hibernate. As soon as hatched,

³⁰⁷Paddock, F. B., Jr. Ec. Ent. VII, p. 14, 1914.

the larvæ begin to tunnel through the comb, feeding upon the wax and lining their burrows with silk. In time the entire comb may be destroyed and rendered a mass of refuse. The length of the larval period varies from forty-five days for the first brood to thirty-five days

for some of the second brood, and to several months for others of the second and for those of the last brood, which pass the winter in this stage. The cocoons are spun during the night around the edges of the frames, in cracks or on the inside walls of the hives or any place near the infested comb.



Fig. 440.—The bee moth, *Galleria mellonella* (Linn.). Portion of cocoons removed to show pupa and larva at left top; pupæ at right top; larvæ in middle; cocoons at bottom. Natural size. (Original)

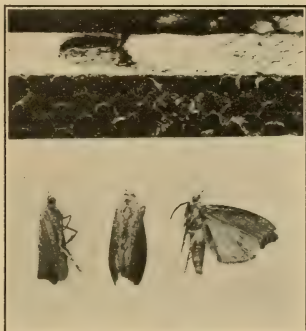


Fig. 441.—The bee moth, *Galleria mellonella* (Linn.). Adult moth resting upon the frame and cocoons on upper side of frame at top; adult females at bottom. Natural size. (Original)

They are often massed side by side in large numbers. The moths move only at night and remain perfectly motionless during the day.

Nature of Work.—The damage to the comb is done by the larvæ and consists in completely destroying it if the ravages are not checked. Large masses of frass and black excrement are usually visible on the surface of the comb or upon the bottom of the hives where infestation occurs. Stored as well as comb honey is attacked.

Distribution.—This moth is generally distributed throughout the bee-raising sections of the State.

Food.—The larvæ feed upon the wax, exuviae and excrement of the honey bee.

Control.—Artificial control of this pest consists in keeping a close watch of the apiary and stored comb honey and in fumigating the hives or infested material with carbon bisulfid at the rate of from $1\frac{1}{2}$ to 2 pounds to 100 cubic feet of air space, or hydrocyanic acid gas at the rate of $2\frac{1}{2}$ ounces of sodium cyanide and proper proportions of sul-

phuric acid and water to every 100 cubic feet of air space. A tight fumigating room may be used for such purposes. Both fumigants should be carefully handled, for the carbon bisulfid is inflammable and the vapor explosive, while the hydrocyanic acid gas is exceedingly poisonous.

Natural Enemies.—The bees themselves, when in healthy condition, are the best means of keeping out the moths and Italian bees especially are destructive to such pests. It is well then to keep the colonies as healthy as possible and to mix in a little of the Italian strain. A small red ant (*Solenopsis* sp.) is cited by Paddock³⁰⁸ as being an enemy of the adults and larvæ of the bee moth. Three internal parasites are reported as occurring in Europe, but so far none are found in America.



Fig. 442.—Larva of the codlin-moth, *Cydia pomonella* (Linn.), in pear. Reduced one half. (Original)

THE CODLIN-MOTH³⁰⁹

Cydia pomonella (Linnaeus) (Family Olethreutidae)

[*Carpocapsa pomonella* (Linnaeus)]

(*Phalena pomonella* Linnaeus)

(Figs. 442-446)

Description.—The eggs are small, flattened to oval in shape, and not larger than a pinhead. When freshly laid they are pearly white. The larva, or so-called "worm," is very minute when first hatched, but when full-grown is nearly an inch long. It is usually pinkish above and whitish underneath. The cocoon is made of white silk and is usually hid away in some sheltered place. The pupa, scarcely over $\frac{1}{2}$ inch long, is first yellowish, turning with age to a dark rich brown. The moth is small, being about one half inch long with a wing expanse seldom greater than $\frac{3}{4}$ inch. The front wings are grayish-brown with several gray or lighter cross lines. Near the tip of each is a small brown spot, in which two irregular golden lines appear. The hind wings are slightly lighter, with fringed borders. The color harmonizes well with the gray bark of the apple and pear trees.

Life History.—The winter is passed in the larval stage within the cocoons upon the trees, in such protected places as under the bark, in split holes, crotches, etc., or beneath trash or litter



Fig. 443.—Adult females and eggs of the codlin-moth, *Cydia pomonella* (Linn.), on young pears. Natural size. (Original)

on the ground, as well as in storehouses where the larvæ have escaped

³⁰⁸Jr. Ec. Ent. VII, p. 188, 1914.

³⁰⁹The cypress cone-borer, *Cydia cupressana* Kear., is very closely related to the codlin-moth. The larvæ are about the same size and dull red or greenish in color. They work in the green cones of the Monterey cypress and are quite abundant in the San Francisco Bay region and along the coast in the central part of the State.

from stored fruit. In the spring they enter the pupal stage, which occupies about twenty days. The first adult moths are ready to emerge about the time the apples bloom, and many continue to appear throughout the spring and summer. They oviposit mainly upon the leaves and twigs, very few eggs being laid upon the fruit. The eggs of the second generation are usually placed upon the fruit. The larvæ hatching from the first eggs usually begin to work immediately upon the leaves while those of the second generation gain entrance to the fruit almost immediately at the calyx end. It requires about twenty days for the larvæ to mature. The generations overlap greatly throughout the summer. The entire life cycle occupies nearly fifty days, there being two broods each year in the Western States.

Nature of Work.—On the fruit of the apple and pear the work of the codlin-moth larvæ is familiar to all and consists in an entrance hole through the side or one end and a dirty mass of frass around the core. Walnuts are also similarly attacked while the husk is still green. If the shell is soft enough to be gnawed through the larvæ feed upon the kernel inside; if not, the burrows are extended around the shell through the green husk.

Distribution.—This moth occurs in all parts of the State, excepting the northern coast counties and not all of these are entirely exempt.

Food.—The fruit of all varieties of apples, pears, quince, and green English walnuts, usually soft-shelled varieties, are attacked. Loquat and crabapple are occasionally infested.

Control.—The accepted treatment for this pest is spraying with arsenicals. The first application should be made just as soon as the petals of the blossoms fall when the sepals of the calyx are open. It will be difficult to find



Fig. 444.—The codlin-moth, *Cydia pomonella* (Linn.). Adults at top; cocoons, pupæ and larvæ at the bottom. Some of the cocoons are opened to show the pupæ. Natural size. (Original)



Fig. 445.—The codlin-moth, *Cydia pomonella* (Linn.). Adult female and pupal case from which it emerged. Natural size. (Original)

a time when all of the calyx cups are the same, but work should be started as soon as possible, and the entire orchard sprayed within a few days. Thorough work with high pressure and liberal applications are necessary. Though one spraying is often deemed sufficient to control this pest, two applications are still recommended by the

best experts. The second spraying should follow the first by three or four weeks. It is a common practice to combine Bordeaux mixture with both of these sprays as a control measure for scab.



Fig. 446.—Adult female of the codlin-moth, *Cydia pomonella* (Linn.). Enlarged four times. (Original)

Natural Enemies.—So far natural control of the codlin-moth has proven very unsatisfactory. Through Mr. George Compere the State has secured a hymenopterous parasite (*Callicephalthes messor*), which preys upon the larvæ just after the cocoons are spun. This parasite has never been able to accomplish any satisfactory results and is no longer being propagated as a natural means of control.

THE FRUIT-TREE LEAF-ROLLER³¹⁰

Archips argyrospila Walker (Family Tortricidæ)

(Fig. 447)

Description.—The prevailing color of the moths is a rusty brown, varying from light to rather dark, with a prominent light spot on the margin near the middle of the front wings and other spots irregularly arranged. With wings closed the length is from $\frac{3}{4}$ inch to $\frac{1}{2}$ inch. The wing expanse is from $\frac{3}{4}$ to 1 inch. The eggs are laid in masses of from ten to one hundred and fifty and are covered with a sticky substance which hardens and protects them during the winter. The masses are very flat and somewhat circular, the diameter varying from $\frac{3}{16}$ inch for the larger to $\frac{1}{16}$ inch for the smaller. (Fig. 447.) When first deposited they are greenish-yellow, but become gray or almost black by winter, and many turn gray in the spring shortly before hatching. Hatched eggs are distinguished by the small holes in the surface. The caterpillars when first hatched are about $\frac{1}{16}$ inch long and light yellow. They later become deep green with the head and thorax shiny brown or black. When full-grown they measure about $\frac{3}{4}$ inch in length. The pupæ are dark brown.

Life History.—The winter is passed in the egg stage upon the trunks and limbs of the host trees, fences, or in fact almost any place,

³¹⁰Weldon, G. P., Mo. Bul. Cal. Hort. Com., Vol. II, pp. 637-647, 1913.
Gill, T. B., Bul. No. 116, pt. V, Bur. Ent., U. S. Dept. Agric., 1913.

and some begin to hatch when the first cluster buds appear in the spring (March and April). The young caterpillars at once enter the opening buds and begin feeding. As the foliage grows the larvæ roll and tie the leaves into compact hiding places which are lined with silken webs. The young fruit is also attacked. The larval stage lasts from twenty-four to thirty-five days. When fully matured they transform to pupæ (last of April and in May) usually within the leaf roll, and in from nine to nineteen days the adults emerge. The females begin to lay eggs within two or three days after they appear (last of May to July). There is but one generation a year.

Nature of Work.—

The first work of the larvæ is in the opening buds and upon the young leaves, blossoms and fruit, all of which may be almost or entirely destroyed. Webs are spun around the

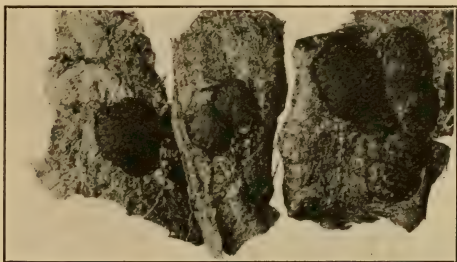


Fig. 447.—Winter egg-masses of the fruit-tree leaf-roller, *Archips argyrospila* Walker. Enlarged three times. Specimens collected in San Diego County by Geo. P. Weldon. (Original)

branches, leaves and fruit, fastening all together. Infested parts of the tree turn brown or the tree may be partially or entirely defoliated in severe cases of infestation, where control measures have not been employed. Fruits attacked when young develop into very irregular and unsightly shapes and are unfit for market purposes. Because of the defoliation the trees are often unable to produce crops for the next year.

Distribution.—Mr. Geo. P. Weldon, who first called attention to this moth in California in 1913, has found it in the following counties: San Diego, Alameda, Solano, Tehama, Santa Clara, San Benito, Santa Barbara and San Bernardino. The writer has received it from Monterey.

Food Plants.—The following food plants are recorded: alfalfa, apple, apricot, cherry, currant, elm, gooseberry, locust, onion, pear, plum, poplar, prune, quince, raspberry and rose.

Control.—It has been fully demonstrated by Mr. Weldon that the application of miscible oil sprays to kill the eggs during the winter is by far the best remedy so far discovered and has given such splendid results as to make further experimentation hardly necessary. During the winter of 1913 Mr. Weldon checked up his experiments previously made in Colorado with miscible oils and other sprays and the efficiency of the former was far ahead of anything else tried, including oil emulsions, lime-sulphur and other commercial sprays. The miscible oils may be had from any spray manufacturing company.

THE OBLIQUE-BANDED LEAF-ROLLER³¹¹*Archips rosaceana* Harris (Family Tortricidæ)[*Cacæcia rosaceana* (Harris)]

(Fig. 448)

Description.—The moths are delicate reddish-brown in color, very flat, and when the wings are folded appear bell-shaped in outline (Fig. 448). The front wings are light cinnamon-brown with many

short darker cross-lines, very fine and irregularly arranged. Near the middle is a wide, dark, oblique band and a large area of the same color near the tips. The hind wings are plain ochre-yellow, with dusky areas near the body. The length is about $\frac{1}{2}$ inch, the wing expanse 1 inch. The caterpillars are light green or pinkish with head and part of prothoracic shield black or dark brown. Sometimes the dorsum is slightly darker than the remainder of the body. The spine areas on the dorsum often appear light, as shown in Fig. 448. When full-grown, they measure $\frac{3}{4}$ inch in length.³¹² The chrysalis is found in the rolled leaf and is of a rich dark-brown color and $\frac{1}{2}$ inch long. The eggs are laid in flat, oval, greenish masses, each mass containing, on an average, over 100 eggs.

Life History.—It appears that no one has studied definitely the stage in which this insect passes the winter and the suggestions of Sanderson and Jackson³¹³ that the larvæ hibernate in rolled leaves or other sheltered places is yet to be definitely proven. Larvæ do appear early in the spring and begin to feed upon the leaves and young fruit, if present, and to tie the leaves together for a place of abode, as does the fruit-tree leaf-roller. Pupation takes place within the rolled leaves and requires from five to eight days. Adults begin to

Fig. 448.—The oblique-banded leaf-roller, *Archips rosaceana* Harris. Larvæ and adult female. Enlarged twice. (Original)

appear in the latter part of April and the first of May. Most of the eggs are laid in August and September and hatch in a little over a

³¹¹Saunders, W., *Ins. Inj. to Fruits*, pp. 90-92, 1911.

³¹²Only part of the dorsum of the prothorax of the caterpillars of *A. rosaceana* is dark while the entire dorsum of the prothorax of *A. argyrospila* is dark.

³¹³Sanderson, E. D., and Jackson, A. D., Jr. *Ent. II*, pp. 391-403, 1909.

week. There are two broods recorded in a number of places, but apparently nothing is known regarding this point in California.

Nature of Work.—The leaves are the principal food of the caterpillars, though young fruit is also eaten and becomes greatly disfigured as it matures. The work is very much the same as that of the fruit-tree leaf-roller.

Distribution.—The species is distributed throughout the central and northern parts of the State. It was received in considerable numbers from Vacaville in April, 1914.

Food Plants.—Sanderson and Jackson³¹³ have listed a large number of food plants, which are included here, as follows: The apple, apricot, ash, basswood, beans, birch, yellow birch, blackberry, box-elder, burdock, carnation, celery, cherry, clover, cotton, currant, dogwood, geranium, gooseberry, hawthorn, hazelnut, honeysuckle, horse-chestnut, knotweed, lilac, oak, peach, pear, plum, poplar, prune, horseradish, ragweed, raspberry, rose, smartweed, strawberry, sumach, sunflower, thistle and verbena.

Control.—Fortunately, this moth has never proven a serious pest so far in this State, but outbreaks may have passed unnoticed. Control measures are somewhat difficult in the orchard, where arsenical sprays repeatedly applied will serve as a means of keeping it in check until the if practiced with regularity and thoroughness.³¹³ The eggs may be destroyed by the application of a miscible oil spray.

THE ORANGE TORTRIX

Tortrix citrana Fernald (Family Tortricidæ)

(Fig. 449)

Description.—The adult insects are gray in color and hardly $\frac{1}{2}$ inch long. The eggs are cream-colored, circular, flat and covered with fine mosaic-like markings. They are laid so as to overlap like the scales of a fish. The larvæ, when full-grown, vary from $\frac{1}{2}$ to $\frac{3}{4}$ inch in length and are white or dusky in color. The chrysalids are brown.

Life History.—The eggs are laid in clusters in early spring, usually upon the undersides of the leaves, each moth depositing about fifty. The eggs hatch in about two weeks and the larvæ feed upon the surface of the orange fruit or upon the foliage or tips of the shoots of the other hosts. Burrows are also made through the peel into the fruit, thus causing decay and ruin. The young reach maturity in about two months. The pupal stage is passed within the old burrow or any protected place outside. The adults emerge in from one to two weeks. The broods overlap, but there are probably three generations a year.

Nature of Work.—The larva makes a clean, round burrow through the rind and sometimes into the pulp of the orange, causing it to fall prematurely or decay.

Fruits which do not decay immediately are ruined for market purposes because of the burrows. The larvæ also sometimes roll the leaves in which they live and occasionally burrow into the tips of the branches.

Distribution.—The moth is a native species and is quite widely distributed throughout the State. It has been injurious only in the southern part.

Food Plants.—The following plants are attacked: acacia, apricot, asparagus, *Cineraria*, Job's tears, eucalyptus, ferns, geranium, golden rod, Jerusalem cherry, *Lantana*, lavender, oak, orange, *Pentas*, rose, wandering Jew, wild black walnut and willow.³¹⁴

Control.—Though the destructiveness to oranges by this insect has been quite great in a few instances, yet not enough actual damage has been done to warrant the application of poison sprays or other methods necessary for control. The parasitic braconids which work upon the larvæ no doubt play some part in the subjection of the pest.

Natural Enemies.—The tachina fly (*Phorocera parva* Bigot.) has been reared from the orange Tortrix at Los Angeles. Internal braconid parasites also work upon it.

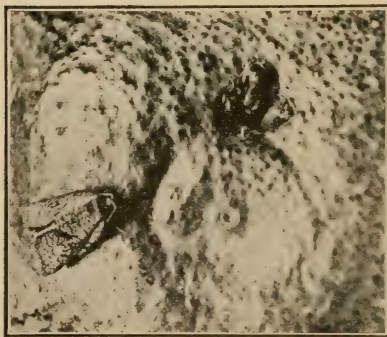
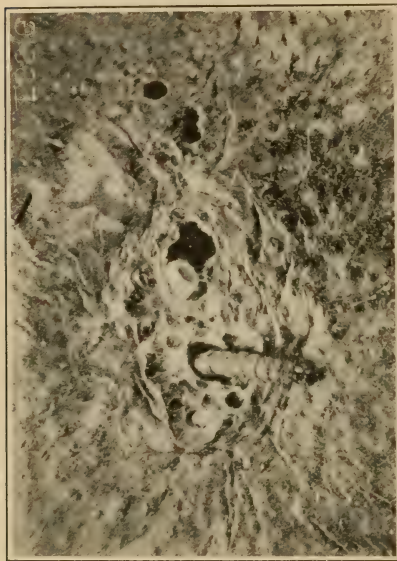


Fig. 449.—The orange Tortrix, *Tortrix citrana* Fernald. Larva and burrows in orange at top; larval burrow and adult on orange at bottom. (Top, author's illustration, Mo. Bul. Cal. Hort. Com.; bottom, after Quayle, Cal. Agrcl. Exp. Sta.)

³¹⁴Quayle, H. J., Jr. Ec. Ent. III, p. 402, 1910.

THE PEACH TWIG-BORER

Anarsia lineatella Zeller (Family
Gelechiidæ)

(*Anarsia pruinella* Clemens)

(Figs. 450-453)

Description.—The adults of this insect are seldom if ever observed by the average orchardist. They are small, between $\frac{1}{4}$ and $\frac{1}{2}$ inch long, and dark silvery-gray in color. The presence of the larvæ is easily told in the spring by the dying back of the young buds and twigs. The larvæ are small, scarcely more than $\frac{1}{2}$ inch long when full-grown. The color varies from pink or dusky-white to dark brown, or almost black. The cocoons are dark brown and are hid away in small protected places.

Life History.—The larvæ hibernate in small chambers or hibernaculæ made just beneath the bark in the crotches, being found most commonly where branches are from $\frac{1}{2}$ inch to 2 inches in diameter. They may be located by the small chimneys of frass pushed out in the process of making (Figs. 450, 351). In the spring, just before or at the time when the leaf buds begin to open, the larvæ leave their places of concealment and seek the young buds for food. They begin to work near the tips in the leaf axils and bore down the center of the stem, killing the tips. By May most have become full-grown. They seek crevices or any suitable place of concealment, and after spinning a frail web over the entrance (Fig. 452) transform into pupæ, and within one or two weeks emerge as adults. Not all of the larvæ are full-grown by May, and the later individuals attack the fruit just as it is beginning to mature in June. It has been thought that the larvæ attacking the fruit were of the second generation and that there was still a third brood, but observations made throughout the state by Geo. P. Weldon and in the Sacramento Valley by the writer seem to show that such is not the case. In fact, the study made by Mr. Weldon on the

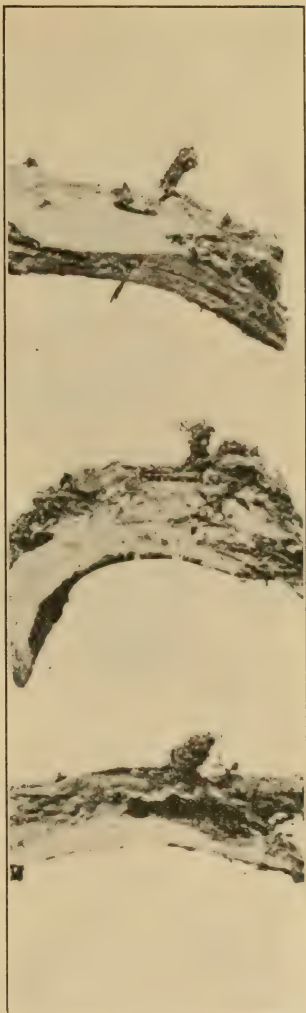


Fig. 450. — Hibernaculæ, or winter chambers of the larvæ of the peach twig-borer, *Anarsia lineatella* Zeller. Enlarged six times. (Original)

habits of this insect, covering the past two years, has led him to believe that there is generally but one rather uneven brood a year. The writer has followed his work closely and shares his view.

The adults of the hibernating larvæ, emerging in May and June, at once begin egg-laying and the young of this brood, instead of attacking fruit, as is generally supposed, begin at once to construct hibernaculæ, where they remain throughout the remainder of the summer and over winter. Mr. Weldon has found these newly constructed chambers as early as May 19th in Ventura County, and from then on until July, after which few if any

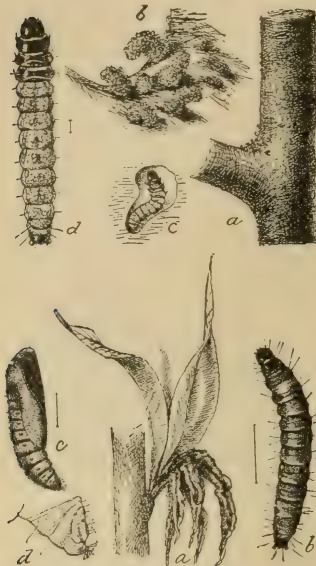


Fig. 451.—The peach twig-borer, *Anarsia lineatella* Zeller. Top: *a*, limb showing location of the hibernaculæ; *b*, chimneys thrown up in constructing the hibernaculæ, enlarged; *c*, larva in the hibernacula; *d*, larva, enlarged. Bottom: *a*, young spring shoot killed by the larva; *b*, larva; *c*, pupa; *d*, posterior tip of pupa. Lines show natural sizes. (After Marlatt, U. S. Dept. Agric.)



Fig. 452.—Web spun across the entrance of the retreat of the pupa of the peach twig-borer, *Anarsia lineatella* Zeller. These are abundant upon the peach trees in the months of May, June and July. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

are made. Perhaps a few larvæ mature before winter and may give rise to a partial second brood, but if so it is very fragmentary and of little importance.

Nature of Work.—The larvæ work in the early spring upon the young buds and shoots and during the summer on the same, as well as on the fruit. The twigs are also attacked. In all such cases the larvæ enter near the tip and work toward the base. During the early spring the young starting buds are often killed before they are more than two inches long. In attacking the fruit they enter at the stem end or side and may work completely around the pit, thus causing rapid decay and complete ruin.

Distribution.—Throughout the peach growing sections of the State.

Food Plants.—The larvæ work upon the tender twigs of almond, apricot, peach, plum and prune trees, peach trees being preferred. They also attack the fruit of the apricot and peach.

Control.—Though once considered a most serious pest, control methods have been perfected which make it no longer a serious menace to the peach grower. These consist of a thorough application of lime-sulphur spray when the buds begin to swell. The commercial prepara-

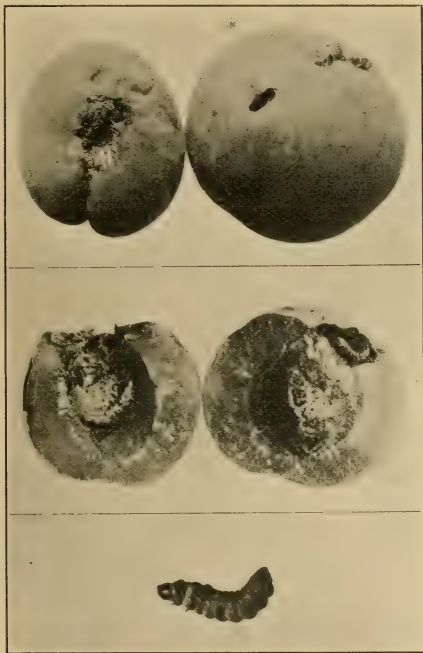


Fig. 453.—Larvæ of the peach twig-borer, *Anarsia lineatella* Zeller, and their work on apricots. Taken at Sacramento in June. Top and middle pictures, natural size; bottom, enlarged twice. (Original)

tion, diluted one part to ten of water and applied as a strong spray under a pressure of from 150 to 200 pounds, is found to give excellent results. Mr. Chas. B. Weeks, Horticultural Commissioner of Tehama County, has been using this formula for a number of years and finds it satisfactory in every way.

Natural Enemies.—In this State a mite, *Pediculoides ventricosus*, is claimed to kill from seventy-five per cent to ninety-five per cent of the larvæ, and an internal hymenopterous parasite, *Hyperteles (Oxy-morpha) lividus* (Ashm.), also preys upon the immature stages.³¹⁵

³¹⁵Farmer's Bul. No. 80, U. S. Dept. Agric., p. 12, 1898.

THE POTATO TUBER MOTH³¹⁶*Phthorimæa operculella* (Zeller) (Family Gelechiidæ)(*Gelechia operculella* Zeller)(*Bryotropha solanella* Boisduval)

(Figs. 454-458)

Description.—The larva varies from white to slightly pink, the head being black. When full grown it is about $\frac{3}{4}$ inch long. The cocoon is spun of fine white web, the chrysalis being light brown in color and about $\frac{1}{2}$ inch in length. The wings of the adults are decidedly gray in color with the bodies silvery. They are about $\frac{1}{2}$ inch long. The eggs are small, globular and pearly white.

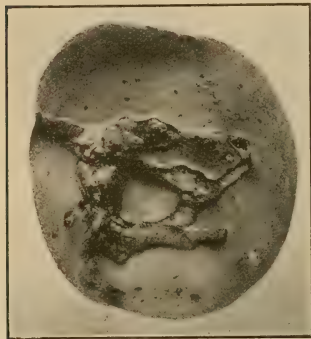


Fig. 454.—Potato showing the burrows of the potato tuber moth, *Phthorimæa operculella* (Zell.). Natural size. (Original)

pupate. During the winter the pupal period may occupy several months, but in the summer and fall from fourteen to twenty days are required. The adults are night flyers and are especially abundant in the fall, particularly when early potatoes are dug. If the tubers are exposed over night the females lose no opportunity to deposit their many eggs, generally over all of them, so as to make a serious infestation. The adults live but a few days.

Nature of Work.—The most characteristic work in this State is that of the larvæ upon the potato tubers, which consists in making burrows through all parts, as shown in Figs. 454, 456. The larvæ also attack the stems and mine the leaves.



Fig. 455.—Larvæ and pupæ of the potato tuber moth, *Phthorimæa operculella* (Zell.). Enlarged one and one fourth times. (Original)

³¹⁶In the Eastern States and other countries this insect is known as the splitworm of the tobacco and the tobacco miner, because of its habits in mining the leaves of tobacco plants.

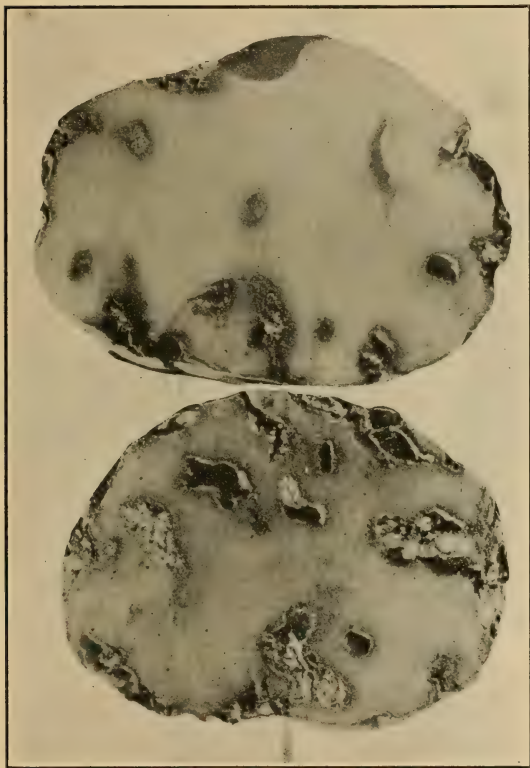


Fig. 456.—Cross-section of potato showing the burrows of the larvæ of the potato tuber moth, *Phthorimæa operculella* (Zell.). Slightly enlarged. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

Distribution.—This moth is quite widely distributed, being reported by county horticultural commissioners from the following counties: Alameda, Contra Costa, El Dorado, Glenn, Kern, Los Angeles, Monterey, Modoc, Napa, Nevada, Orange, Placer, Riverside, Sacramento, Shasta, San Benito, San Bernardino, San Diego, San Joaquin, San Luis Obispo, Santa Clara, Santa Cruz, Shasta, Stanislaus, Ventura and Yolo.

Food Plants.—The following are hosts of this moth: cat-tail, egg-plant, horse nettle, ground cherry, nightshade, potato, tobacco and tomatoes.

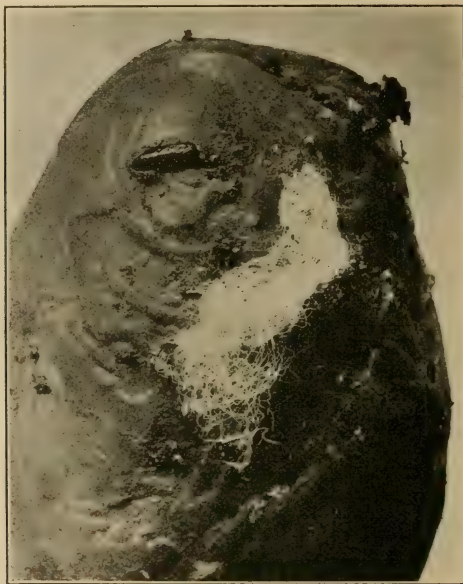


Fig. 457.—Cocoons and pupa of the potato tuber moth, *Phthorimra operculella* (Zell.), on potato. Natural size. (Original)

Control.—All host plants should be kept from growing in or around the potato fields. Deep planting and hilling should be practiced to prevent access to the tubers. The potatoes should be dug as early as possible and not allowed to remain in the fields over night, unless sacked.

In tobacco seed-beds the application of a spray composed of 1 ounce arsenate of lead to 16 gallons of water has given good results.

In places of general infestations the tubers may be thoroughly disinfected before storing, by soaking them in water for thirty-six hours. This method is claimed by some shippers to ruin the potatoes. Heavy fumigation (3 ounces of potassium cyanide per 100 cubic feet) has been recommended to kill the larvæ in infested potatoes, but even such

a dose does not appear to kill all of the young and is not a sure exterminator. In the storage bins, one to two pounds of carbon bisulfid to every one thousand cubic feet of air space for forty-eight hours is



Fig. 458. — Adults of the potato tuber moth, *Phthorimura operculella* (Zell.). Enlarged three times. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

claimed sufficient to kill the eggs, and for fifteen to sixteen hours to kill the larvæ in the tubers. Three or four fumigations will not hurt the potatoes, according to the experiments of F. Steward.³¹⁷

In some places crop rotation is advised, and grain, corn, forage crops or beets, beans, etc., are recommended. The rotations should never be for a period less than five or six years.

THE ANGOUMOIS GRAIN MOTH

Sitotroga cerealella (Olivier) (Family Gelechiidæ)

(*Gelechia cerealella* Olivier)

(Fig. 459)

Description. — The adult females are light-yellowish, iridescent-brown, with few darker markings on the front wings. They average about one inch in length, including folded wings. The very small eggs are oval-elongate and slightly pinkish in color. The larvæ are scarcely over $\frac{1}{4}$ inch long, but more often small enough to comfortably occupy the inside of a wheat or barley kernel. They are robust and white. The pupæ are pale yellowish-brown.

³¹⁷Rept. Australia Assn. Adv. of Sci., Vol. XIV, pp. 328, 329.

Life History.—In grains, the eggs are deposited on the outsides of or between the kernels in the head or on the cob. They are laid in the field in late summer and fall, but in storehouses egg-laying may continue throughout the year. As soon as the young hatch they bore a very minute hole and work their way into the interior of the kernel. In wheat and barley only one individual occupies the interior, while in corn there may be several or many. The larval and pupal stages are passed within the kernel, which is completely destroyed. The adult insect emerges through a small circular hole cut in the thin wall and escapes to mate, soon to start other broods. The life cycle occupies about forty days, there being many overlapping broods a year. In bins of grain, breeding is very rapid and great destruction is wrought in a very short time.

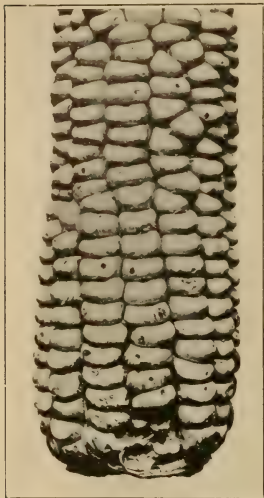


Fig. 459.—Ear of corn showing the exit holes of the Angoumois grain moth, *Sitotroga cerealella* (Oliv.). Slightly reduced. Specimen received from O. E. Bremner, Santa Rosa. (Original)

Nature of Work.—The larva works within the kernel, entirely destroying the interior and leaving a small round exit hole.

Distribution.—This moth occurs throughout the southern and central parts of the State.

Food Plants.—As the common name infers, this moth attacks grains, including barley, wheat and corn.

Control.—The crops should be harvested as soon as possible to prevent infestation in the field. For treatment in storage, see same under granary weevil, page 307.

THE CALIFORNIA CASE-BEARER

Calcephora sacramenta Heinrich²¹⁸ (Family Elachistidæ)

(Figs. 460, 461)

Description.—The cases in which the larvæ and pupæ are concealed are iridescent black with golden or yellow markings around the large or anterior end, which is curved under. The case is widened at the anterior end with the sides folded in and under, as shown in Fig. 460. The shape apparently does not change at all. The bottom is flat, allowing the case to lie close against the leaf. The length is $\frac{5}{16}$ inch. The adults (Fig. 461) are small, slender, delicate white moths. The fore wings are white and faintly peppered with brown scales. The hind wings are dull lead-gray. The joints of the antennæ are alternately marked white and black, resembling a row of alternating white and black beads. The females are about $\frac{1}{2}$ inch long.

²¹⁸This new species was discovered and collected by Leroy Childs and named by Mr. Carl Heinrich through the kindness of Dr. L. O. Howard and Mr. A. Busck. (Insec. Insci. Mens. II, p. 145, 1910.)



Fig. 460.—Pupa cases of the California case-bearer, *Coleophora sacramenta* Heinrich, on prune leaves. Natural size. Specimens collected in Santa Clara County by Leroy Childs. (Original)

Life History.—This moth is a new insect and other than a few field observations, nothing is known of its life history. Mr. Leroy Childs, who discovered it, found the pupæ quite thick upon prune trees in Santa Clara County, May 6, 1914. The work of the larvæ was also in evidence, but had been done some time previous to that time. There is usually only one case to a leaf, but occasionally two, three and even four or five may be found.

Nature of Work.—The larvæ eat ragged holes in the margins and through the leaves, as shown in Fig. 460.

Distribution.—So far this species has been taken only in Santa Clara County, but inasmuch as it is a native species it probably occurs elsewhere along the middle coast region.

Food Plant.—It has so far been taken only upon the prune, but probably also works upon other fruit trees.

Control.—The arsenical sprays, applied as soon as the caterpillars begin to feed in the spring, as recom-



Fig. 461.—Adults of the California case-bearer, *Coleophora sacramenta* Heinrich, on prune leaf. Natural size. Reared from pupæ collected in Santa Clara County by Leroy Childs. (Original)

mended for the cankerworms, will also control the case-bearer. Remedial measures have never been necessary to control this insect.

THE ORANGE PEEL MINER

Marmara sp. (Family Tineidæ)

(Figs. 462, 463)

Description.—The adults of this miner are unknown, having never been reared or determined. The larvæ are exceedingly small, yellowish and distinctly segmented, as shown in Fig. 463. The anterior segment is noticeably large and bears two small projections. The length is about $\frac{3}{8}$ inch.



Fig. 462.—Orange showing the work of the orange peel miner, *Marmara* sp. Natural size. Specimen taken in San Bernardino County by S. A. Pease. (Original)

the peel. The skin above the mines soon becomes colorless and later the entire affected portion turns brown.

Distribution.—The miner appears to be quite generally distributed in the southern part of the state, but is more often found attacking oranges in the inland districts of San Bernardino, Riverside and the eastern portion of Los Angeles counties.

Food.—The peel of the orange is the only known food of this insect, though it undoubtedly attacks native vegetation.

Control.—The amount of damage is so exceedingly small that control measures are not at all necessary.

Life History.—The life history has never been worked out. The mines appear on the peel just before the fruit is ready to pick, from November to March. Where the remainder of the year is spent is not known, but probably as some leaf miner on native vegetation.

Nature of Work.—Fig. 462 shows very well the characteristic work of the orange peel miner and consists of long irregular intertwining mines just beneath the epidermis of

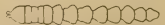


Fig. 463.—Larva of the orange peel miner, *Marmara* sp. Enlarged three times. The specimen was taken from the mine shown in Fig. 462. (Original)

THE CYPRESS MOTH

Argyresthia cupressella Walsingham (Family Hyponomeutidæ)

(Fig. 464)

Description.—The moths are very small, bright, iridescent golden or yellow, with three light brown bands across the front wings, the tips of which are also brown, as shown in Fig. 464. The hind wings are light yellow. Both pairs of wings are fringed with long light yellow hairs, which are dark at the tip of the front wings. The length of the moths is about $\frac{3}{16}$ inch, the wing expanse nearly $\frac{1}{2}$ inch. The eggs are yellowish-green when first laid, turning reddish or pink with age. They are strongly convex and slightly elongated. The surface is finely sculptured. The length is $\frac{1}{32}$ inch. The larvæ or caterpillars are light green or whitish with a reddish dorsal spot on the eighth segment of the older ones. The prothoracic shield, head and mandibles are brownish. When disturbed they hang by a silken thread. The pupæ are light brown, about $\frac{1}{4}$ inch long and are inclosed in white cocoons attached to the twigs.



Fig. 464.—The cypress moth, *Argyresthia cupressella* Walsingham. Larva, pupa, larval cell in tip of twig and adults. All slightly enlarged. Specimens collected in Golden Gate Park, San Francisco, by Harold Compere. (Original)

Life History.—The eggs are laid singly upon the small terminal twigs, usually near the base, in the axil of the leaflets. As soon as hatched the larvæ enter the twigs and burrow downwards for about an inch. Several twigs may be attacked by a single caterpillar. When fully matured the larvæ leave the burrows and spin small white cocoons on the twigs in which to pupate. According to D. W. Coquillett, the larvæ appear in February and April and the adults in April and early May. Eggs remain over winter and hatch in the spring.³¹⁹ From the observations of the writer in the Golden Gate Park, San Francisco, where this moth is a serious pest, at least some of the eggs hatch in the fall and the larvæ spend the winter within the burrows. Adults appear in April and are still plentiful in June and the first of July, when the eggs are being laid. Mr. Harold Compere has observed larvæ in their burrows the last of December, pupæ in May and adults and eggs during the last of May and sometimes afterwards. By the middle of May all larvæ have pupated and adults are plentiful until fall. There are apparently two broods a year.

Nature of Work.—The larvæ burrowing into the tips cause them to enlarge and finally to die. The exit hole is always plainly visible. In

³¹⁹Insect Life, III, p. 116–118, 1890.

cases of serious infestation so many of these tips are killed that the tree appears brown and very unhealthy.

Distribution.—The cypress moth occurs in the central and southern parts of the State.

Food Plant.—The Monterey cypress is the only host so far reported of this pest.

Control.—Thorough and regular pruning will usually suffice to control this pest in hedges. Where trees are grown for windbreaks or other than for hedges liberal applications of lead arsenate when the eggs are hatching in the fall or spring are advised.

THE CALIFORNIA PARSLEY CATERPILLAR³²⁰

Papilio zolicaon Boisduval (Family Papilionidæ)

(*Papilio zelicayn* Lucas)

(*Papilio californica* Menetries)

(Fig. 465)

Description.—The butterfly is one of the smaller swallow-tails having a wing expanse from 2 to 3½ inches. The color is black and orange-yellow, each being about equal in extent, the yellow being distributed along the edges and in the middle of the wings. The caterpillars are yellowish-green with continuous and broken black



Fig. 465.—Larva and pupa of the California parsley caterpillar, *Papilio zolicaon* Boisd. Enlarged one and one half times. (Author's illustration, Mo. Bul. Cal. Hort. Com.)

bands around the body and having an orange-yellow forked scent organ just back of the head which is thrown out when disturbed. When full grown they are about 2 inches long. The chrysalids vary from green to dull gray, somewhat mottled and about 1 inch long. The eggs are small, rounded, reddish-brown and about $\frac{1}{16}$ inch long.

Life History.—The eggs are laid singly upon the plants in the spring and after hatching the caterpillars at once begin to feed upon the foliage

³²⁰This is the common celery and parsley caterpillar found in California. *Papilio polyxenes* Fab., listed as such in the first edition, is reported as being very rare in this State. The above species (*P. zolicaon* Boisd.) was also listed as the California orange dog in the first edition.

of the host plants. In a month they become full grown and then attach themselves by the tail-end to a stem or other suitable place and transform to chrysalids, which change into butterflies about two weeks later. There are one or two broods a year. The winter is passed in the pupal stage.

Nature of Work.—The caterpillars feed upon the foliage, often stripping off all of the leaves.

Distribution.—This butterfly is widely distributed and may be found in all parts of the State. It is specially abundant in the Sacramento and San Joaquin valleys.

Food Plants.—The natural food plants of this insect are various species of *Umbelliferae*, the most favored ones being celery, parsley, *Faniculum vulgare* and *Carum kelloggii*. In the Porterville section, as well as in the vicinity of Riverside, it has been claimed that the larvæ feed upon orange trees.³²¹

Control.—The caterpillars occur singly and in rather few numbers upon the trees, but their ravenous appetites and ability to consume great amounts of foliage often make control necessary. As they are easily located, hand picking is the remedy recommended.

Natural Enemies.—Fortunately natural enemies play a large part in the control of this insect, otherwise greater damage would be done. Mr. Karl R. Coolidge,³²¹ who first called attention to it as an orange pest, states that a tachina fly and a species of *Apanteles* prey upon the larvæ.

THE IMPORTED CABBAGE WORM³²²

Pontia rapæ (Linnaeus) (Family Pieridæ)

[*Pieris rapæ* (Linnaeus)]

(*Papilio rapæ* Linnaeus)

(Figs. 466, 467)

Description.—Though this is an imported pest, it has become as common as if it had always been here. The butterflies are white, $\frac{1}{4}$ inch long and with a wing expanse of 2 inches. The tips of the front wings are black or dusky. The females have two dark spots on each front wing and one near the front margin of the hind wing, while the males have a single black spot near the middle of each front wing and a spot on the hind wing similar to that of the female. The eggs are white or pale yellow, pointed with a rather wide, flat base, and the surface is distinctly ribbed. The caterpillars are light velvety green, covered with many minute black specks. When full grown they are from 1 to $1\frac{1}{2}$ inches long. The chrysalids vary from yellowish green to gray and are about 1 inch long.

Life History.—In the northern part of the State the species winters over in the pupal stage, while in the south adult butterflies may be seen almost any time of the year. They become very much in evidence early in March and are active throughout the entire summer and fall.

³²¹P. C. Jr. Ent. Vol. I, p. 334, 1910.

³²²There are five other species of *Pontia* which attack cruciferous plants in California. Of these the southern cabbage butterfly, *Pontia protodice* (Boisd.), is sometimes a serious cabbage pest. It is easily separated from *P. rapæ* (Linn.) by the large number of black spots on the wings, as shown in Fig. 468.



Fig. 466.—The imported cabbage worm, *Pontia rapae* (Linn.). Eggs on nasturtium leaf at top, enlarged twice; larvæ in the middle, natural size; chrysalis at the bottom, natural size. (Original)

Egg-laying begins soon after the adults leave the pupal stage. The eggs hatch in about a week and the young caterpillars begin feeding at once. They first feed upon the outer leaves, making them ragged and full of holes, but gradually work through towards the heart of the cabbage, leaving the dark-green excrement to mark their paths of destruction. The growth is very rapid, so that in from one to two weeks they are ready to select some secluded spot beneath an old cabbage leaf or some nearby object and prepare for the pupal stage, which, during the first two generations in the summer months, lasts little longer than the larval stage, but which in the fall continues throughout the winter. There are several generations a year. In fact, in the southern part of the State it seems as if the breeding is only slightly checked during the winter months.

Nature of Work.—The caterpillars, or “worms,” as they are commonly called, devour the leaves of many plants, but are specially fond of cabbage, which they attack in all stages of its growth. The leaves of young plants are partially eaten and assume a ragged appearance. The outer leaves of cabbage heads may also show a similar condition, but usually the larvæ eat into the heads, making tunnels throughout and leaving dark-green excrement, which is very repulsive, to mark their paths. Much damage is thus done and cabbage growers annually lose large sums because of this pest.

Distribution.—This butterfly is very common in every part of the State.

Food Plants.—The caterpillars feed on quite a number of plants, some of which are brussels sprouts,

cabbage, cauliflower, horseradish, kale, mignonette, mustard, nasturtium, radish, rape, sweet alyssum and turnip.

Control.—The larvæ, working as they do into the heads of the cabbages, make control measures practically impossible after they have once begun. Young plants may well be protected by arsenical sprays, which are applied with safety until the heads are half-grown. Clean

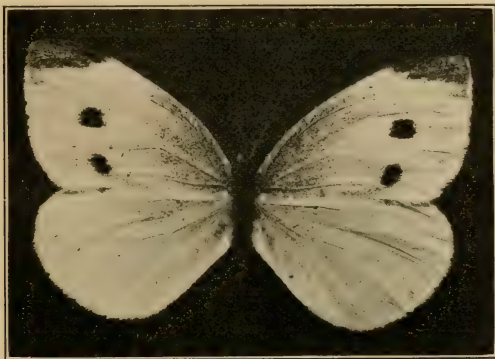


Fig. 467.—Female butterfly of the imported cabbage worm, *Pontia rapa* (Linn.). Enlarged one and one half times. (Original)

culture should be practiced and no cabbage or host plants allowed to grow during the interval between crops unless they are freely sprayed with strong solutions of arsenicals. Spraying with white hellebore kills the caterpillars without danger to the plants or the consumer. Fortunately most of the cabbage grown in California is raised near the ocean, during the winter, and is usually quite free from this pest.



Fig. 468.—The southern cabbage butterfly, *Pontia protodice* (Boisd.). Male and female. Natural size. (After Riley)

Natural Enemies.³²³—Internal parasites which attack the chrysalids are important factors in the reduction of the numbers of the cabbage worm. In California the hymenopterous parasite, *Pteromalus puparum* Linn., is quite widely distributed and often quite effective. *Apanteles glomeratus* Linn. is common in the Eastern States, and was recently introduced into California by the State Insectary. Wolf's ambush bug, *Phymata wolffi* Stal., destroys the butterflies, while the wheel bug, *Arilus cristatus* Linn., the spined soldier-bug, *Podisus maculiventris* Say, and the wasp, *Polistes pallipes* Lepel., are predaceous upon the caterpillars. The tachina fly, *Erorista vulgaris* Fall., is parasitic upon the larvæ.

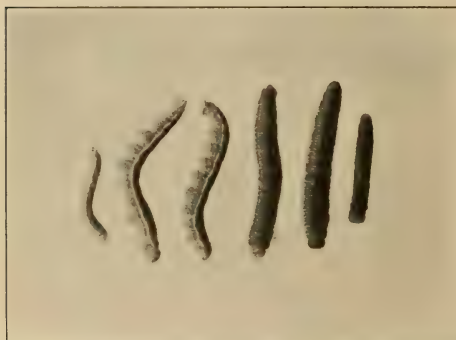
THE ALFALFA CATERPILLAR³²⁴

Eurymus eurytheme (Boisduval) (Family Pieridæ)

(*Colias eurytheme* Boisduval)

(Figs. 469–471)

Description.—The predominating color of the butterflies is a rich orange-yellow, reddish-yellow or sulphur-yellow, though some are much lighter. The upper outer margins of the wings are dark and there is a black spot near the front margin in the middle of the front wings



and a deep orange spot near the middle of the hind wings. The antennæ are reddish with dusky knobs. The length of the females is about 1 inch, with a wing expanse of 2 inches. The males are slightly smaller. The eggs are very minute, distinctly ribbed and cross-lined, white when first laid, becoming brownish with age. They are deposited upon the new growth. The caterpillars

Fig. 469.—Larvæ of the alfalfa caterpillar, *Eurymus eurytheme* (Boisd.). Natural size. (Original)

are about 1 inch long and dark green in color with a distinct and sometimes a faint white line on each side. The openings of the spiracles are black and red. The dorsum is often darker than the remainder of the body. The pupæ are yellowish-green, $\frac{3}{4}$ inch long and suspended to the stalks, head up.

³²³Insect Life, III, p. 16, 1890.

Chittenden, F. H., Cir. No. 60, Bur. Ent., U. S. Dept. Agric., 1905.

³²⁴Wildermuth, V. L., Cir. No. 133, Bur. Ent. Dept. Agric., 1911, and Bul. No. 124, U. S. Dept. Agric., 1914.

The light sulphur-yellow butterflies have usually been considered a distinct species, *Eurymus philodice* (Godart), but are now thought to be but a color phase of the alfalfa caterpillar. (Bul. 124, U. S. Dept. Agric., p. 14, 1914.)

Life History.—The insect hibernates in the adult and pupal stages, the adults beginning to emerge early in the spring, about the first of March. They immediately begin egg-laying in the alfalfa fields. The caterpillars become very numerous and destructive during the summer months. This was especially true during the year 1913, when thousands of the butterflies hovered over nearly every acre of alfalfa from Imperial to Modoc counties. In the San Joaquin Valley they appeared especially destructive. Hay fields suffered most, but pastured fields were seriously injured. There are two generations in the colder regions and six or more in the warmer southern sections, according to Wildermuth.

Nature of Work.—The larvæ strip the leaves from the plants, leaving only bare stalks.

Distribution.—This butterfly occurs throughout the entire State.



Fig. 470. — Adults of the alfalfa caterpillar, *Eurymus eurytheme* (Boisd.). Enlarged one and one fourth times. (Original)

Food Plants.—Alfalfa appears to be a favorite host of this butterfly, but many other plants are attacked, some of which are the following: *Trifolium reflexum*, *T. stoloniferum*, white clover (*T. repens*), *T. tridentatum*, *Lotus* sp., loco-weeds (*Astragalus caryocarpus* and *A. crocalariae*), sweet clover (*Melilotus alba*), soja bean, peas and vetch.

Control.—To successfully control such a pest one must resort to a number of practices, all of which judiciously combined will give very good results. The alfalfa should be cut, as soon as the larvæ begin to

appear in any numbers in the spring, to starve this first brood and thus keep down the next generation. Other cuttings should be made when



Fig. 471.—Cocoon of *Campoplex* sp. on alfalfa leaf. The larvæ of this parasite attack the larvæ of the alfalfa caterpillar. Enlarged four times. (Original)

blooming begins. Successive irrigations immediately after cutting to stimulate vigorous growth is very important. Disking the fields in the fall of the year will kill many of the over-wintering pupæ. The food plants should not be allowed to grow wild around the fields, as they serve for excellent breeding places. Pasturing the land also helps to keep down the pest.

Natural Enemies.—Mr. Wildermuth records the following natural enemies: the tachina flies, *Phorocera claripennis* Macq. and *Frontina archippivora* Will.; the phorid, *Aphiochata perdita* Malloch; the hymenopterous egg parasites, *Apanteles flaviconche* Riley, *Chalcis ovata* Say, *Pteromalus euryymi* Gahan and *Trichogramma minutum* Riley. The author has collected quite a number of the pupal cases of a *Campoplex* sp. (Fig. 471) which is evidently parasitic upon the larvæ. A bacterial disease also kills large numbers of the larvæ and pupæ in damp weather.

THE MOURNING CLOAK BUTTERFLY

Eurancassa antiopa (Linnæus) (Family Nymphalidæ)

[*Vanessa antiopa* (Linnæus)]

(*Papilio antiopa* Linnæus)

(Fig. 472)

Description.—The butterflies are purplish-black with noticeable yellow wing borders or margins, in which is a row of pale blue spots. The wings are also noticeably notched or toothed along the margins. The bodies are about 1 inch long, the wing expanse from 3 to 3½ inches. The caterpillars are black, besprinkled with minute white specks and a row of eight brick-red spots along the back. The surface is rough, each segment bearing from six to seven branched spines, giving the whole caterpillar a decidedly spiny appearance. When full-grown they are from 1¾ to 2 inches long. The chrysalids are dark brown with light yellow spots upon the back and from ¾ to 1 inch long.

Life History.—The adults hibernate and are sometimes seen on bright days in midwinter. They begin egg-laying about the first of March. The eggs are laid upon the leaves and around the twigs of the host plants and the caterpillars move from plant to plant as the food becomes scarce. They are social in habits and often appear in such large numbers as to completely defoliate quite large areas. There are two broods a year.

Nature of Work.—The caterpillars devour the leaves, thus defoliating portions or entire trees.

Distribution.—This species is commonly distributed throughout the State.

Food Plants.—Balm of Gilead, birch, elm, hackberry, linden, poplar and willow are among the food plants.

Control.—The application of poison sprays as soon as the caterpillars first appear in the spring will easily control this pest. Cutting and burning the branches upon which a colony is located will often exterminate a small infestation. These control measures would not justify the costs, except in small gardens.

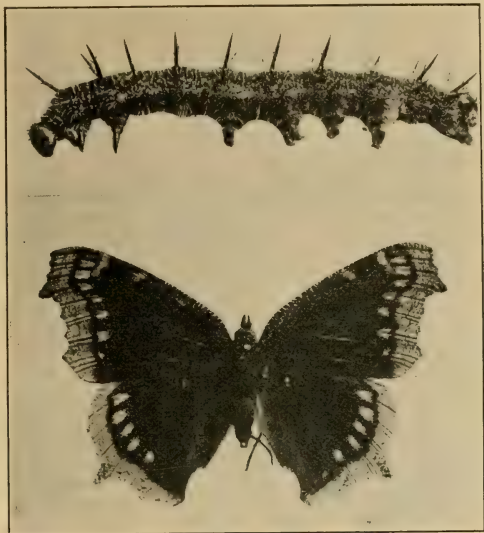


Fig. 472.—Larva and adult of the mourning cloak butterfly, *Euryanassa antiopa* (Linn.). Natural size. (Original)

THE THISTLE BUTTERFLY

Vanessa cardui (Linnaeus) (Family Nymphalidae)³²⁵

[*Pyrameis cardui* (Linnaeus)]

(*Papilio cardui* Linnaeus)

(Fig. 473)

Description.—The butterflies are deep orange or red with white, black and dark brown markings, as shown in the illustration (Fig. 473). The length is about $1\frac{1}{4}$ inches and the wing expanse is 2 inches. The full-grown caterpillars are black or dull brown with a distinct pale or yellow stripe on the side. The spines are rather long and forked, as in all larvæ of the nymphalids. The length averages from $1\frac{1}{2}$ inches to 2 inches. The chrysalises are iridescent brown, or appear as if dipped in molten gold. They are about 1 inch long.

Life History.—The adults appear in the spring and deposit

³²⁵This species is generally replaced in the central and northern parts of the State by a closely related species, *Vanessa caryæ* Hübn. It is distinguished by a black band across the cell of the front wings.



eggs—usually upon one of the food plants—from which the caterpillars hatch in a short time. During March and April they often become very abundant. This was particularly true in 1914. When fully matured they hang up by the tail and transform into chrysalids, which mature, in from one to two weeks, into butterflies. There are apparently several broods a year, the spring brood being usually the largest. This species sometimes migrates in great numbers, the flights lasting a week or more, as the migration in 1902. All fly in one direction.

Nature of Work.—The caterpillars devour the leaves and smaller stems of the food plants, often leaving only the larger woody stalks.

Distribution.—This butterfly is very common throughout the southern part of the State, but occasionally appears in the central and northern parts in somewhat limited numbers.

Food Plants.—Ordinarily the caterpillars feed only upon wild non-economic plants, as thistle, malva, *Amsinckia*, nettle, marsh-mallow, etc., but occasionally garden plants, especially beans, are attacked.

Control.—The elimination of the host plants around the fields of cultivated crops will usually serve to keep the latter free from attacks. However, if infestation occurs poison sprays may be employed, but not on vegetables soon to be used for food. Control measures are seldom necessary for this butterfly.

Natural Enemies.—An internal hymenopterous parasite, *Apanteles carduicola* Pack.³²⁶ has been reported as preying upon this species.

³²⁶Insect Life, III, p. 16, 1890.

Fig. 473.—The thistle butterfly, *Vanessa cardui* (Linn.). Larvæ, pupæ and adults. Natural size. (Original)

SPRAYS AND POISONS

Spraying for insect pests has become a very important factor in the growing of a large number of crops and especially in horticultural work. As such it is now a regular and well established business which has received a very large amount of investigational work, with the result that there are today efficient sprays for most of the important ailments a tree or plant is heir to. This is true of both the home-made and commercial products, and it is often an exceedingly difficult task for the orchardist and farmer to select a preparation or formula which will give the best results for the outlay of money.

It is beyond the limits of any ordinary work to give a complete list of the formulæ and uses of all the preparations which may be designated as home-made products, and it is none the less prohibitory to give a list of all the commercial insecticides now upon the market. However, it is the desire of the writer to give the formulæ and methods of preparation of some of the most important which can be made at home or the equivalents of which may be obtained from commercial manufacturers.

In general insecticides, whether they be liquids, solids or gases, are usually listed in three main classes, viz: arsenical, contact and repellent. The arsenical sprays are used in controlling biting and chewing insects which are capable of taking the poison internally. They are the cheapest and therefore used wherever practical. The contact sprays are for piercing and sucking as well as biting and chewing insects which can not be controlled by arsenicals. The gases and repellents are used for all classes of insects; the gases kill directly and the repellents, being distasteful, prevent or repel attacks.

ARSENICAL INSECTICIDES FOR BITING AND CHEWING INSECTS

Paris green and London purple were the first arsenicals used as insecticides, but of late years it has been discovered that lead arsenate and zinc arsenite, while not quite as strong, are much less liable to damage the fruit and foliage and have therefore largely replaced the stronger arsenicals. Paris green, however, is still used for certain insects, and where there is no danger to foliage as in the use of baits, it is used very largely. White arsenic is also used for this purpose and is much less expensive.

Arsenicals are largely used in combating such insects as grasshoppers, armyworms, cutworms, caterpillars, slugs, beetles, or any others which actually eat the foliage or fruit.

LEAD ARSENATE³²⁷

A. Lead arsenate (paste).....	4 to 8 pounds
Water	100 gallons
B. Lead arsenate (powder).....	2 to 8 pounds
Water	100 gallons

³²⁷There are two kinds of lead arsenate on the market—the ordinary, or acid, which is generally used and at times causes severe burning to fruit and foliage if applied too strong, and neutral lead arsenate, which is perfectly safe and should be used wherever there is any danger of burning tender fruit and foliage, or usually in combination when other insects or fungi are to be sprayed at the same time.

Mix the paste or powder in the required amount of water or first in a small amount and add the remainder for use. See that the mixture is thoroughly agitated when spraying in order to keep the lead arsenate in proper suspension.

Lead arsenate is rendered none the less effective when combined with Bordeaux mixture, iron sulfid or tobacco decoctions, but the acid type should never be used in combination with oil emulsions, soap sprays and doubtfully with lime-sulphur. The neutral type, however, may be used safely with any of the above.³²⁸

PARIS GREEN

If lead arsenate can not be had, Paris green may be used as follows:

Paris green	1 pound
Air-slaked lime (or better, dry water-slaked lime)	5 pounds
Water	200 gallons

First stir the poison into a thin paste with a little water, add this to the lime, then strain the mixture through a sieve into a tank containing the required amount of water. *It is particularly necessary to keep this mixture well agitated while spraying.*

As a dust, Paris green is mixed as follows:

Paris green	5 ounces
Air-slaked lime	1 pound

The Paris green and lime are thoroughly powdered, mixed and dusted upon the plants through a muslin bag or by means of a blower.

Paris green may be effectually used when combined with Bordeaux mixture and iron sulfid, but should never be applied in combination with lime-sulphur, soap sprays and emulsions. It should not be used on trees prior to fumigation, as severe burnings are sure to result.³²⁸

POISON BAITS

Poison baits occupy a very important place in the control of certain insects, such as grasshoppers, armyworms, cutworms, wireworms, etc., and are especially useful to the small gardener, though they have often been used with excellent results in large fields and orchards.

POISON BRAN MASH

No. 1.	
Bran	25 pounds
Paris green	$\frac{1}{2}$ pound
Cheap molasses	1 quart
No. 2.	
Bran	40 pounds
White arsenic	5 pounds
Molasses	2 gallons

In preparing these mix the arsenic or Paris green and bran dry, and add the molasses, which has been diluted in water. Add enough more water to moisten the bran so that it will appear between the fingers when the mixture is squeezed in the hand.

Some prefer to moisten the bran first and afterward stir in the molasses and poison.

³²⁸Gray, Geo. P., Mo. Bul. Cal. Hort. Com., Vol. III, pp. 265-275, 1914.

CRIDDLE MIXTURE

Though this mixture is somewhat disagreeable to make and handle, it is exceedingly cheap and effective, especially for grasshoppers.

Fresh horse dung.....	60 pounds
Common salt.....	2 pounds
Paris green.....	1 pound

The Paris green is mixed with enough water to form a paste and is then stirred thoroughly into the horse dung with the salt.

These poisoned baits are scattered about in fields infested with grasshoppers, armyworms, cutworms and various other destructive chewing insects or they may be placed in advance of the oncoming hordes. A very important thing in handling the poisoned baits is to see that they are kept moistened all the time, as they become worthless when dry. To prevent this drying out the mixture should be put out in small piles and occasionally moistened. They may also be placed under boards or in the shade, while for cutworms and wireworms it is often advisable to bury them in the ground. According to Prof. C. W. Woodworth, this mixture has not proven very effective in California. It should only be used where grasshoppers are observed to gather freely on fresh horse dung.

CITRIC BRAN MASH

A mash recommended by Hunter and Claassen²²⁰ has been used in this State very successfully to combat grasshoppers. The formula is in two parts as follows:

Part I.	
White arsenic (or Paris green).....	2½ pounds
Bran.....	50 pounds
Mix these dry.	
Part II.	
Lemons (chopped fine, including rind).....	½ dozen
Syrup or molasses (cheap).....	4 quarts
Water.....	5 gallons
Mix these together.	

Mix Part I and Part II and add enough water to make a wet mash. The parts should not be mixed until ready for use. Distribute broadcast in front of the pests early in the morning.

CONTACT INSECTICIDES FOR SUCKING AND BITING INSECTS

LIQUIDS**LIME-SULPHUR**

Lime-sulphur is easily the most important insecticidal spray now used, and its fungicidal properties make it even more useful to the orchardist. It is especially valuable for controlling scale insects, the peach twig-borer and fungi on deciduous fruit trees, though if properly weakened it may also be used as a summer spray, particularly for the red spiders and mites.

²²⁰Hunter, S. T.; and Claassen, P. W., Jr. Ec. Ent. Vol. VII, p. 76, 1914.

Formerly lime-sulphur spray was a home-made product, but today the commercially prepared product is so much more convenient than the home-made mixtures and as good as the best that can be made on the farm that the use of the latter has almost ceased.

HOME-MADE LIME-SULPHUR

Formula

Stone lime -----	50 pounds
Sulphur, flowers of -----	110 pounds
Water to make -----	50 gallons

Preparation.—Heat in a cooking barrel or vessel about one third of the total quantity of water required. When the water is hot, add all of the lime, and at once add all the sulphur, which should previously have been made into a thick paste with water. After the lime is slaked, another third of the water should be added, preferably hot, and the cooking should be continued for an hour, when the final dilution may be made, using either hot or cold water as is most convenient. The boiling due to the slaking of lime thoroughly mixes the ingredients at the start, but subsequent stirring is necessary if the wash is cooked by direct heat in kettles. After the wash has been prepared it must be strained through a fine sieve as it is being run into the spray tank. The resultant product is a concentrated solution of lime-sulphur, which should be diluted for use as directed in the table for diluting the commercial lime-sulphur.

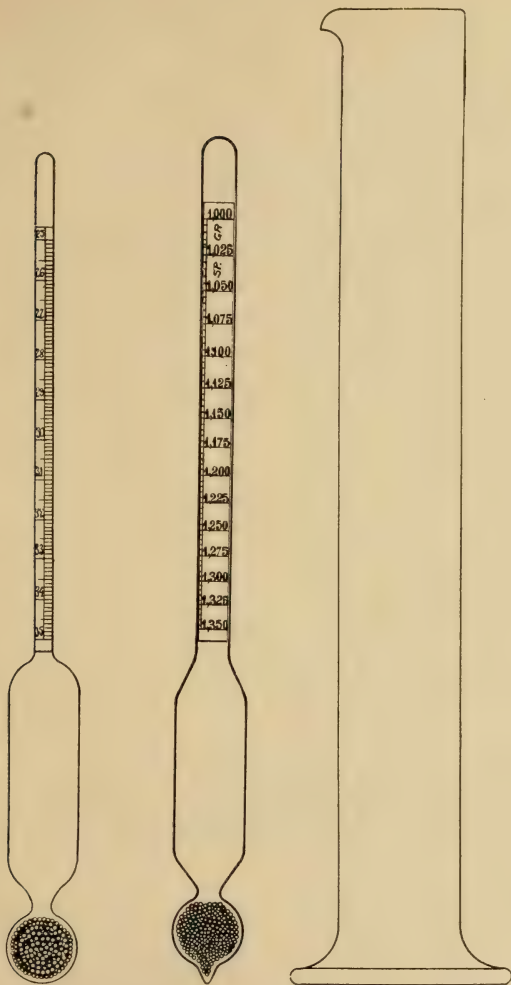


Fig. 474. — Instruments for ascertaining the exact dilution of lime-sulphur. Beginning at the left, Baumé hydrometer; specific gravity hydrometer; hydrometer cylinder to hold liquid being tested. (After Bausch & Lomb Optical Co.)

COMMERCIAL LIME-SULPHUR

The commercial lime-sulphur is a perfectly clear liquid needing only to be diluted for use. Because of its dependency it is fast replacing the home-made preparations. There are three common brands upon the market in California under the trade names "Rex," "Ortho" and "Orchard," though there are many other brands which may be obtained elsewhere.

In using the lime-sulphur it is very important to have just the right amount of dilution. This is ascertained by the use of a Baumé or specific gravity hydrometer as shown in Fig. 474. The following table has been worked out for the use of these instruments:

TABLE SHOWING THE DILUTIONS FOR DORMANT AND SUMMER SPRAYING WITH LIME-SULPHUR MIXTURES³²⁰

Reading of hydrometer		Amount of dilution. Number of gallons of water to one gallon of lime-sulphur solution		
	Specific gravity	For San Jose scale	For blister-mite	For summer spraying
33 degrees Baumé.....	1.3299	11	13	46 $\frac{1}{2}$
35 degrees Baumé.....	1.3181	9	12 $\frac{1}{2}$	45
34 degrees Baumé.....	1.3063	8 $\frac{3}{4}$	12	43 $\frac{1}{4}$
33 degrees Baumé.....	1.2946	8	11 $\frac{1}{2}$	41 $\frac{1}{2}$
32 degrees Baumé.....	1.2831	8	11	40
31 degrees Baumé.....	1.2719	7 $\frac{1}{2}$	10 $\frac{1}{2}$	37 $\frac{3}{4}$
30 degrees Baumé.....	1.2608	7 $\frac{1}{4}$	10	37 $\frac{1}{4}$
29 degrees Baumé.....	1.2500	6 $\frac{3}{4}$	9 $\frac{1}{2}$	34 $\frac{1}{4}$
28 degrees Baumé.....	1.2393	6 $\frac{1}{2}$	9	32 $\frac{3}{4}$
27 degrees Baumé.....	1.2288	6	8 $\frac{1}{2}$	31
26 degrees Baumé.....	1.2184	5 $\frac{3}{4}$	8	29 $\frac{1}{2}$
25 degrees Baumé.....	1.2083	5 $\frac{1}{4}$	7 $\frac{1}{2}$	27 $\frac{1}{4}$
24 degrees Baumé.....	1.1983	5	7	26
23 degrees Baumé.....	1.1885	4 $\frac{3}{4}$	6 $\frac{1}{2}$	24 $\frac{1}{2}$
22 degrees Baumé.....	1.1788	4 $\frac{1}{4}$	6	22 $\frac{3}{4}$
21 degrees Baumé.....	1.1693	3 $\frac{3}{4}$	5 $\frac{1}{2}$	21 $\frac{1}{4}$
20 degrees Baumé.....	1.1600	3 $\frac{1}{2}$	5	19 $\frac{3}{4}$
19 degrees Baumé.....	1.1507	3 $\frac{1}{4}$	4 $\frac{1}{4}$	18 $\frac{1}{4}$
18 degrees Baumé.....	1.1417	3	4 $\frac{1}{4}$	17
17 degrees Baumé.....	1.1328	2 $\frac{3}{4}$	4	15
16 degrees Baumé.....	1.1240	2 $\frac{1}{2}$	3 $\frac{3}{4}$	15
15 degrees Baumé.....	1.1153	2 $\frac{1}{4}$	3 $\frac{1}{2}$	14

LIME-SULPHUR AND FLOUR PASTE

For spraying trees in foliage and tender plants a lime-sulphur flour paste spray has given remarkably good results. The following formulæ are recommended:

No. 1.

Water	200 gallons
Flour paste, 8 pounds flour in	8 gallons water
Sublimed sulphur	10 pounds
Lime-sulphur solution	2 $\frac{1}{2}$ gallons

The flour is first made into a thin paste by adding one pound to each gallon of water, according to the above formula. The sulphur is made into a paste also and added with the flour paste and lime-

³²⁰Parrott, P. J., Bul. No. 320, N. Y. Agrcl. Exp. Sta., 1909.

Parrott, P. J., and Schene, W. J., Bul. No. 330, N. Y. Agrcl. Exp. Sta., 1910.

Stewart, John P., Bul. No. 115, Pa. Agrcl. Exp. Sta., p. 17, 1912.

sulphur solution to the two hundred gallons of water in the spray tank. This spray is excellent for the red spiders on almond and citrus trees. Minus the lime-sulphur solution it is a very effective spray for the two-spotted mite (*Tetranychus telarius*) on hops.

No. 2. (Iron Sulphide.)

Water -----	200 gallons
Flour paste, 8 pounds flour in -----	8 gallons water
Lime-sulphur solution -----	2½ gallons
Iron sulphate -----	4 pounds

This spray is mixed as the preceding, and the iron sulphate after being dissolved is added directly to the diluted mixture in the tank.

The above spray is especially recommended for late summer sprayings for red spider on almond and citrus trees, but should not be applied to fruit trees just before the fruit is ready to pick, as the fruit might be stained.

LIME-SULPHUR IN COMBINATION WITH OTHER SPRAYS²⁸

Lime-sulphur may be used in combination with tobacco sprays and applied with safety on citrus trees prior to fumigation. It should not be combined with Paris green, acid lead arsenate, zinc arsenite, oil emulsions and soaps. With neutral lead arsenate, however, no damage may result.

EMULSIONS AND MISCIBLE OILS

Emulsions are oil sprays in which soap is most frequently used as an emulsifying agent. They have a high power of penetration and a rapid and even distribution over the sprayed surface. With ordinary care they may be readily made at home and are very valuable as insecticides.

In the miscible oils the emulsifier is incorporated in the oil. The proportions must be very exact and vary according to the variation in the composition of the oil and other ingredients, and is therefore not practical to be made at home. The miscible oil sprays are the highest type of emulsions and are almost universally employed for commercial purposes.

KEROSENE EMULSION

There are two general types of kerosene emulsion, as follows:

Cook Emulsion.—In this emulsion there is a larger amount of soap. It is the easiest to make, slightly more expensive and usually about as effective if made with a good grade of fish oil soap. The general formula is

Fish oil soap -----	1 pound
Kerosene -----	½ gallon
Water -----	2 gallons

This was the first attempt at making an emulsion of this type and was a great discovery in insect control. It was invented by Dr. A. J. Cook, the present State Commissioner of Horticulture.

Riley-Hubbard Emulsion.—In this emulsion the proportion of soap does not vary far from ¼ pound to a gallon of oil. It requires very

vigorous agitation, the oil going quickly into the creamy condition of the Cook emulsion, but after further agitation it thickens into a clabber-like material. The formula is

Fish oil soap	-----	$\frac{1}{2}$ pound
Kerosene	-----	$\frac{1}{2}$ gallon
Water	-----	1 gallon

Preparation.—The preparation of both of the above emulsions is about the same and consists in first dissolving the soap in the hot water, after which the kerosene is added and the whole thoroughly and vigorously agitated by pumping it into itself until a thick creamy liquid results. Soft water should be used wherever possible, as it is almost essential to obtaining a proper emulsion.

For use on dormant trees and plants in the winter dilute the stock solution one to five of water. On trees or plants in foliage dilute with ten parts of water.

In giving directions for diluting kerosene emulsion many writers recommend the use of a certain per cent. This is exceedingly confusing to the average orchardist, and in order to have the information necessary to follow these recommendations the following dilutions showing per cent of strength are taken from O'Kane.³³¹

For 4% strength add	15 $\frac{1}{2}$ gallons of water to 1 gallon of stock solution
For 5% strength add	12 $\frac{1}{2}$ gallons of water to 1 gallon of stock solution
For 7% strength add	8 gallons of water to 1 gallon of stock solution
For 10% strength add	5 gallons of water to 1 gallon of stock solution
For 12% strength add	4 $\frac{1}{2}$ gallons of water to 1 gallon of stock solution
For 15% strength add	3 gallons of water to 1 gallon of stock solution
For 18% strength add	2 gallons of water to 1 gallon of stock solution
For 20% strength add	2 gallons of water to 1 gallon of stock solution
For 25% strength add	1 gallon of water to 1 gallon of stock solution

DISTILLATE EMULSION

Distillate (28 degrees Baumé)	-----	20 gallons
Whale oil soap	-----	30 pounds
Water to mix	-----	12 gallons

Dissolve the whale oil soap in the water, heating it to the boiling point; add the distillate and agitate thoroughly while the solution is hot. For use add twenty gallons of water to each gallon of the above mixture.

CARBOLIC ACID EMULSION

Whale oil soap	-----	40 pounds
Crude carbolic acid	-----	5 gallons
Water to mix	-----	40 gallons

Dissolve the soap in hot water (the soap must be entirely dissolved); add the carbolic acid and heat to the boiling point for twenty minutes (reserve some water to add in case the mixture begins to boil over). For use add twenty gallons of water to every gallon of the above stock solution. The emulsion needs little or no agitation.

This spray is especially recommended for mealy bugs, but is also suitable for plant lice and soft brown scale. It is also a good contact insecticide for ants.

³³¹Injurious Insects, W. C. O'Kane, p. 74, 1913.

CRUDE OIL EMULSION

Water	175 gallons
Liquid soap	3 gallons
Crude oil (21°-24°)	25 gallons

Fill the spray tank with the 175 gallons of water; add the liquid soap; agitate thoroughly for one minute, after which add the crude oil, continuing the agitation.

If the liquid soap can not be had, use 20 pounds whale oil soap, dissolved in 10 gallons of boiling water, to which three pounds of lye have been added.

During the spraying operation this mixture should be thoroughly agitated and great care taken to wet all of the twigs. From 8 to 15 gallons should be used on a tree. The application should be made from November to February.

The crude oil emulsion is especially recommended for black scale (*Saissetia oleæ*), European fruit Lecanium (*Lecanium corni*), European pear scale (*Epidiaspis piricola*), cherry scale (*Lecanium cerasorum*) and other scales infesting deciduous fruit trees. It should be applied in the winter, when the trees are dormant.

To also kill moss or lichens on fruit trees add two pounds of lye to the formula of the stock solution.

DISTILLATE OIL MECHANICAL MIXTURE

Water	200 gallons
Caustic soda (95 per cent)	7 pounds
Distillate (28 degrees Baumé)	10 gallons

Fill spray tank with the required amount of water; add the distillate and caustic soda, which has been dissolved in a small amount of water. Keep agitator going rapidly while applying the spray.

This spray has been thoroughly tested by the writer and is one of the cheapest and best for spraying black scale (*Saissetia oleæ*) or the European fruit Lecanium (*Lecanium corni*) on apricot and olive trees.

DISTILLATE EMULSION AND TOBACCO

(Government Formula for Pear Thrips)

Water	12 gallons
Whale oil soap	30 pounds
Distillate (32 to 34 degrees Baumé)	20 gallons

The above emulsion is prepared in the ordinary way as a stock solution. For use in the orchard dilute one to twenty parts of water. To every two hundred gallons of this diluted spray add one pint of tobacco extract containing forty per cent nicotine or about three and one half gallons of tobacco extract containing 2 $\frac{3}{4}$ per cent nicotine.

This spray is especially recommended for pear thrips. (Also see control measures under pear thrips.)

ROSIN WASH.

Though not a true emulsion and fast losing prominence as a spray, this wash is included here because of its value as a spray and dip for plants with tender foliage.

Rosin -----	10	pounds
Caustic soda (76 per cent) -----	3	pounds
Fish oil -----	1½	pounds
Water -----	50	gallons

Put oil, rosin and a gallon of water in an iron kettle and heat until the rosin is softened; add the caustic soda (dissolved in a small amount of water) and stir thoroughly, after which add enough water to make fifty gallons of spraying material.

This wash is only effective for young scale insects, plant lice, or other soft-bodied insects.

SOAP WASHES

A simple and easily prepared spray for use in small gardens is made from soap as follows:

Whale oil or hard laundry soap -----	1	pound
Water -----	5	gallons

The soap is first dissolved in a small amount of hot water and the remainder added afterward. This spray will not injure tender plants or foliage, and is recommended only for young scale insects, plant lice and other soft-bodied insects.

SOAP POWDER

Among the recent commercial insecticides is a soap powder which readily dissolves in hot or cold water and has very good insecticidal powers. The amount of dilution varies with the product, but is usually 1 pound to 5 or 6 gallons of water or as stated on the container.

TOBACCO DECOCTIONS

For soft-bodied insects in greenhouses, conservatories, or on house plants, as well as for plant lice, leaf-hoppers and other similar insects in the open, the tobacco decoctions are invaluable because they do not injure the foliage and give excellent killing results.

Home-made Extract

Tobacco leaves or stems -----	1	pound
Water -----	4	gallons

Steep the tobacco in the hot water and apply directly.

Commercial Extracts

The extract containing 2½ per cent nicotine should be diluted to sixty parts of water. The extract containing 40 per cent nicotine should be diluted from one to one thousand parts or one to fifteen hundred parts of water.

DUSTS

A number of valuable insecticides are applied dry as dusts. We have already referred to Paris green and lime as being used in this

way. Dusts are easy to mix and handle and are often of great service to the farmer and orchardist.

FLOWERS OF SULPHUR

For a number of years flowers of sulphur was used alone as a remedy for mites on citrus and almond trees. It was distributed over the trees by hand or with a blower in the early morning when the foliage was damp, thus enabling it to adhere. The warm sunshine volatilizes some of the sulphur and oxidizes a part so as to liberate two gases, which are killing factors. Accordingly sulphur is of little avail in the cool summer weather of the coast counties or during the winter months anywhere. However, in the warm interior districts this is still a very effective remedy for mites.



Fig. 475.—A power blower for applying dusts in orchards. About forty acres can be treated in one day with such a machine.

SULPHUR AND LIME

Even better than sulphur alone is hydrated lime and flowers of sulphur mixed in equal parts and blown upon the trees with a power machine, as is shown in Fig. 475. In the citrus orchards this is a very important method of controlling the citrus red spider (*Tetranychus mytilaspidis*) and the two-spotted mite (*Tetranychus telarius*).

LIME, SULPHUR AND SAL BORDEAUX

This mixture is prepared as follows:

Hydrated lime (dry, finely powdered, water-slaked lime)-----	40 pounds
Flowers of sulphur-----	5 pounds
Sal Bordeaux (a mixture of bluestone, charcoal and naphthol)-----	5 pounds

Mix these ingredients thoroughly and apply with a power blower. This is one of the most efficient preparations now being used in controlling the red spider (*Bryobia pratensis*).

MILLED SULPHUR.

This is sulphur to which something else is added to make it possible to grind it exceedingly fine. It is known by the trade names, atomic sulphur and diatomic sulphur. It is very good for red spider and mites.

PYRETHRUM

This is commonly known as Persian or Dalmatian insect powder, or Buhach, and comes as a finely ground yellow powder with a pleasant, rather pungent odor. It is a contact poison and most larvæ and soft-bodied insects are thrown into convulsions when they come under its influence. Unfortunately it is not only expensive but quickly loses its effectiveness when exposed to the air. Its practical range is therefore limited, and it is chiefly used on house plants, in the conservatory and in the garden. It is entirely harmless to vegetation of all kinds and does not spot or mark even the most delicate flowers when used dry. It acts a little more promptly and effectively if applied to the insects while they are moist, or at least damp. If the dusty appearance is objectionable, a decoction may be made by steeping one ounce in one quart of boiling water, and then adding two or three quarts of cold water. Into this material potted plants may be dipped, or it may be applied with an atomizer. For plant lice on house plants this makes a very clean and effective application.

HELLEBORE

Powdered white hellebore has been used for many years as a specific remedy against "currant worms," "rose slugs" and other saw-fly larvæ, and is very effective, either dusted on as a powder, or in the form of a decoction. In the field it is now quite generally replaced by arsenate of lead or even Paris green, but in the garden it still holds its own. When applied, it may be used pure, or it may be mixed with two or three times its own weight of dust, cheap flour, lime, or almost any other light, finely powdered material. When used as a spray, steep one ounce in one quart of boiling water and add another quart of cold water when ready to apply.

It is also quite effective against certain root maggots, like those affecting cabbage and cauliflower. For these it is used in the form of a decoction, one ounce in one gallon of water and about half a pint poured around an infested plant, from which the earth has been drawn away to facilitate soaking directly around the plant. To be effective, the material must be brought into direct contact with the insects. Hence, it should be liberally used and applied before the maggots get down too far, or into the plant too deeply. In the garden its use is quite practical; in the field it has not been found so satisfactory.

REPELLENTS

It is apparent that certain materials, applied to the foliage of plants, are somewhat repulsive to some insects. One of the most important of these repellents is the well known fungicide, Bordeaux mixture. Because of this and its use as a combined insecticide and fungicide the formula and directions for making are here presented quite fully.

BORDEAUX MIXTURE

Unslaked lime -----	4 pounds
Copper sulphate (bluestone) -----	4 pounds
Water -----	50 gallons

The task of mixing these chemicals, where large quantities of the spray is used, is no small thing in itself. A great deal of study has been given to the construction of suitable mixing apparatus.

The first consideration is to get the materials high enough on a platform so that they can be easily and rapidly placed in the spraying tanks of the power machines. This is done by constructing at convenient places in the orchard platforms large enough to hold a large box for slaking lime, a lime solution agitator, and a vat for dissolving the bluestone. Such a platform is about 12 feet square and $4\frac{1}{2}$ feet high. A large standpipe for filling the tanks is desirable or the water must be pumped into the tank while the solutions are being added.

The lime is first slaked in a common vat for that purpose. The great trouble has always been to keep the slaked lime agitated properly when it was being drawn off to mix with the bluestone in the spraying tank. This problem has been solved by the use of a special agitator for this purpose. The lime from the slaking vat is strained into this tank through the slanting bottomed strainer. The agitator works by means of a hand lever and the contents of the tank may be thoroughly mixed in a few minutes before it is drawn off for use. Here it is again strained through the strainer as is also the bluestone.

The bluestone vat has slats, across the entire box, or simply across one end. These slats must be low enough so that the bluestone, which is placed upon them in sacks, will be completely immersed in the water. This method admits quick dissolving of the bluestone, much more rapidly than if simply poured into the tank and stirred.

The lime and bluestone are mixed with a given amount of water so that the proper quantities of the resultant solutions can be measured so as to give the mixture the strength of the above formula.

The sieve used should be made of brass wire and contain twenty meshes to the inch.

This spray is usually used as a repellent for the flea-beetles, cucumber beetles, diabrotica, and other leaf-eating insects.

Bordeaux mixture may be used in combination with Paris green, lead arsenate (acid and neutral), calcium arsenite and in some instances with rosin soap for special purposes, but should not be combined with tobacco or used prior to fumigation.³²⁸

BANDS

To prevent insects from crawling up the trunks of trees and plants various bands have been devised which have proven exceedingly successful in many instances.

Tanglefoot.—Tree tanglefoot is a thick, sticky substance which, when applied as a band, remains moist for several weeks and is a very effective barrier against cankerworms, caterpillars, cutworms, Fuller's rose beetle and other crawling insects.

The material is put up in cans. It should be applied directly to the trunk of the tree several feet above the ground.

Sticky Rope.—In the work on the California tussock moth, W. H. Volck recommends the use of rope bands saturated in an easily prepared mixture as follows:

Castor oil -----	1 gallon
Rosin -----	16 pounds

The rosin and castor oil are gently heated until the former is completely melted. If too thick more oil may be added. The bands dipped in this mixture should be replaced by new ones about every ten days.

Crude oil rich in asphaltum or a mixture of equal parts of pine tar and molasses have also given satisfactory results.

Cotton Bands.—Bands of loose cotton fastened around the trunks of the trees are excellent in preventing the ascent of insects.

Oiled Paper.—Oiled paper tied around the trunks of small vines and plants is an old method which sometimes proves practical today.

WHITEWASH

Besides being used as a direct insecticide in many cases whitewash is often used indirectly to protect the trees against sunburn and thus ward off attacks of borers which seek entrance at any weakened place. There are many formulæ for preparing this mixture, two of the more important of which are given below.³³²

ORDINARY WHITEWASH

Water -----	2 gallons
Quick lime -----	10 pounds

The lime is placed in a pail and the water added, after which the pail is covered with a couple of canvas sacks or heavy material and allowed to stand for an hour. If the lime is transparent and lumpy it has been scorched, due to the lack of sufficient water. After slaking add enough water to bring it to a brush consistency.

WEATHERPROOF WHITEWASH

A more durable whitewash is prepared as follows:

(1) Quick lime -----	62 pounds
Water (hot) -----	12 gallons
(2) Common salt -----	2 pounds
Sulphate of zinc -----	1 pound
Water (boiling) -----	2 gallons
(3) Skimmed milk -----	2 gallons

³³²From "White Paints and Painting Materials," by W. G. Scott.

Slake the lime thoroughly in (1); dissolve the salt and sulphate of zinc in two gallons of water (2); pour (2) into (1) and add (3). Mix thoroughly. Two pounds of flour paste (dissolved in 2 gallons of hot water) may be added instead of the skimmed milk.

THE APPLICATION OF SPRAYS

EQUIPMENT

The proper application of any spray is without doubt the most important factor in all spraying work. A very poor product well applied often gives much better results than a good product poorly applied. How much better, then, the thorough application of a reliable product.

Pumps.—The procuring of a good pump is the first step. In this the purchaser must be guided entirely by the amount of spraying he has to do. For small yards and gardens or for young orchard trees

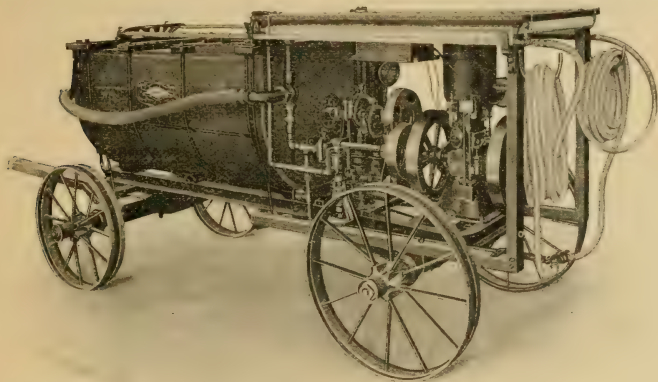


Fig. 476.—A power spraying machine for general orchard work. (Courtesy Bean Spray Pump Company)

the ordinary foot and bucket pump is satisfactory. The knapsack pump is also a convenient apparatus, especially for spraying young orchard trees where there is much walking and little spraying.

For small orchards of from five to ten acres hand pumps with pressure tanks and from one to two leads of hose, such as shown in Fig. 477, do very well and give complete satisfaction if great care is taken to keep the solution in the tank well stirred and the application is made thorough. The absence of an agitator is a great handicap to any hand machine, especially if oil sprays or arsenicals are used.

For orchards of from ten to twenty acres small power pumps are adequate, but even in such orchards a good power machine will pay for itself in a very short time. High pressure and thorough agitation

the great essentials in spraying work, can only be had with a good power machine. Such a machine is shown in Fig. 476 and is able to supply two or four leads of hose with an adequate pressure. Orchardists owning only small orchards are clubbing together and buying a power sprayer for several orchards and find this a convenient way of getting first-class work done cheaply.

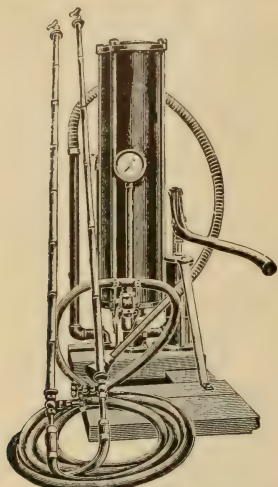


Fig. 477.—A good hand pump with pressure gauge. Only one lead of hose should be used to get the best results. (After Bean Spray Pump Company)

work. For general spraying pounds, while 200 pounds is operator to reach every part of the tree or plant in a very short time.

Nozzles.—At present there are many names applied to different types and styles of nozzles, but there are only two types extensively sold.

Many growers, however, use a single type for all kinds of spraying work.

The cyclone type (Fig. 478) includes the large styles known by such trade names as "Jumbo," "Whirlpool," "Mistry Jr.," "Friend," etc. All of these nozzles can be adjusted to meet the needs of different kinds of work by simply changing the disc, enlarging or reducing the size of the hole and also the quantity of spray delivered.

For truck crops an entirely different machine has been devised. Some growers have mounted the ordinary power pumps upon a satisfactory wagon and have made attachments for spraying rows. A geared sprayer, such as shown in Fig. 481, is certainly a most commendable machine, making it possible to spray rapidly, thoroughly and with little cost of operation. Such a pump is recommended for spraying potatoes, tomatoes, corn, peas or any other crops sown in rows or broadcast.

Blowers.—For the application of dust sprays, hand and power machines are manufactured. With the blower shown in Fig. 475 it is possible to cover from twenty to sixty acres in a single day, thus reducing the cost of application to a very small amount.

Pressure.—With a good pump there will be little difficulty in maintaining sufficient pressure, which is a great consideration in doing thorough and rapid the pressure should not fall below 150 still better. Such pressure enables the

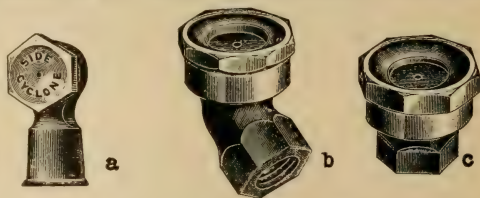


Fig. 478.—Cyclone spray nozzles. a, small side nozzle for spraying trees and plants infested with red spiders or mites; b, angle, and c, straight "Jumbo" nozzles, excellent for general work. (After Bean Spray Pump Company)

The Bordeaux type (Fig. 480), is used largely in the application of Bordeaux mixture and the arsenicals, but it is also used for all kinds of work by many orchardists. The nozzle is easily adjusted by the stop-cock and is specially adapted for clogging sprays or whitewash, for they can be cleaned simply by turning the stop-cock once around and blowing out the obstruction.

It has been demonstrated that an angle nozzle (Fig. 478 b) is far superior to the straight form for most purposes, in that it admits of a much greater variety of work, allowing the operator to spray at will in any direction by a slight turn of the wrist.

For a power pump and two leads of hose, two angle nozzles on a straight "Y" (Fig. 479) or two straight nozzles on an angle "Y" to



Fig. 479. — Straight and angle "Y." The "U" shaped form is much better than one with a "V" shaped fork as shown at the right, because the spray is forced straight ahead instead of sideways. Angle nozzles should be used on the straight "Y" and straight nozzles on the angle "Y." (After Bean Spray Pump Company)

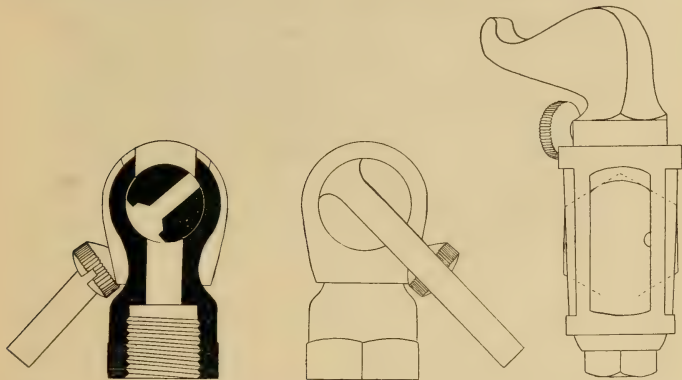


Fig. 480.—Drawing, showing construction and exterior views of a Bordeaux nozzle. Natural size. (Courtesy Prof. C. W. Woodworth, Cal. Agrcl. Exp. Sta.)

each lead of hose, has given very satisfactory results where a great spread of the spray is desired.

THOROUGHNESS

Great care should be taken to make the application thorough in every respect. The material should not only be well agitated but applied to every portion of the tree. Most of the unsatisfactory results in spraying are due to inefficient and careless operators. Every portion of the tree should be thoroughly drenched. The tips of the side branches and the tops should receive the same careful consideration as is usually given to the trunk. No one can hope for good results who neglects this important phase of spraying work.

TIME OF APPLICATION

Of course the time of application varies somewhat with each particular pest, but there usually is a best time for every one. The grower should carefully ascertain when that time is and do the work then

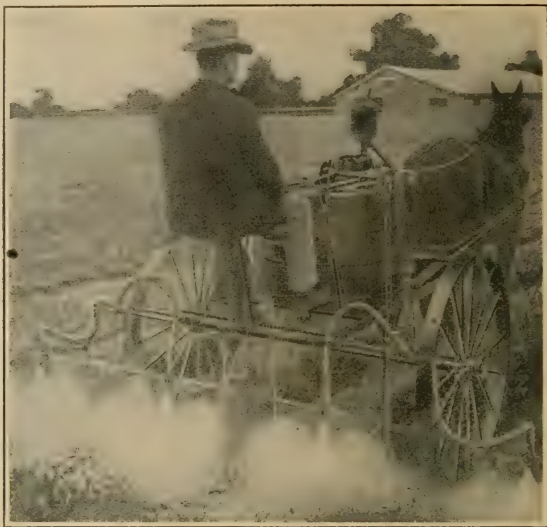


Fig. 481.—A geared spraying machine for garden and truck crops.

and not wait until his efforts are of little or no avail. Those who spray for such insects as the codlin-moth can appreciate best what the time element means.

FUMIGATION³³³

Fumigation consists in the generation and uses of gases to kill pests. Formerly such practices were limited to the uses of carbon bisulfid, sulphur dioxid and tobacco fumes. The use of hydrocyanic acid gas in citrus orchards has lately been so perfected as to become of very great importance and has opened up a remarkable field in the control of orchard pests.

CARBON BISULFID

Carbon bisulfid is a liquid which evaporates into a heavy, highly inflammable and explosive gas. It was first used for fumigating beans, grains or cereals for weevils, and is still a very efficient method of controlling such pests. In handling the liquid great care should be taken to keep it away from a flame on account of the vapor being highly explosive.

FOR STOREHOUSE PESTS

Before fumigation is begun care should be taken to see that the room or container is made as tight as possible. The temperature should be 70 degrees Fahrenheit or above, for poor and unsatisfactory results are sure to follow even excessive doses at a lower temperature. In a tight compartment, 5 pounds of carbon bisulfid to every 1,000 cubic feet of air space will give excellent results in killing weevils. If the compartments can not be made tight, increase the amount of the fumigant.

FOR ROOT PESTS

Carbon bisulfid has also been used in the fields to kill root pests like the woolly apple aphid, black peach aphid, grape phylloxera, white grubs, root-maggots, but is far too expensive to be practical and is effective only in soils of just the right degree of porosity. For a small plant, a hole is made in the ground near the base and a teaspoonful of the liquid poured into the hole, which is covered to prevent surface evaporation. For larger plants several holes are made deep enough to allow the vapor to disseminate around the infested roots. A syringe-like instrument is sometimes used to inject the liquid into the soil around the roots of the infested plants. In all such work care must be exercised in making the applications or the plants may be killed by an excessive dose or by the carbon bisulfid coming in direct contact with the roots.

FOR WOOD-BORERS

Carbon bisulfid is also injected into the burrows of wood-boring insects with some success, but this method has never met with much favor, perhaps because in many cases the burrows are open only after the damage has already been done and the insects escaped.

³³³For further information relative to fumigation, see

Bul. No. 76, Bur. Ent., U. S. Dept. Agric. Exp., by A. W. Morrill
 Bul. No. 79, Bur. Ent., U. S. Dept. Agric. Exp., by R. S. Woglum.
 Bul. No. 90, (Part I) Bur. Ent., U. S. Dept. Agric. Exp., by R. S. Woglum.
 Bul. No. 90, (Part II) Bur. Ent., U. S. Dept. Agric. Exp., by R. S. Woglum.
 Bul. No. 152, Cal. Agrcl. Exp. Sta., by C. W. Woodworth.
 Circular No. 11, Cal. Agrcl. Exp. Sta., by C. W. Woodworth.
 Circular No. 50, Cal. Agrcl. Exp. Sta., by C. W. Woodworth.

FOR ANTS' AND WASPS' NESTS

A small amount of carbon bisulfid poured into the underground nests of ants, wasps, yellow jackets and other insects of like habits will usually exterminate the colony. This method, however, is of little avail against the Argentine ant, because of the many small nests.

TOBACCO FUMES

For very tender house and greenhouse plants infested with plant lice, thrips and other small insects or mites, it is sometimes advisable to fumigate them with slowly burning tobacco, to avoid injury to the foliage, but even in such cases hydrocyanic acid gas, if properly handled, is much better and is gradually replacing the tobacco punk and other commercial fumigants of a similar nature.

HYDROCYANIC ACID GAS

Hydrocyanic acid gas is usually generated by the addition of cyanide to diluted sulphuric acid. The generation is made in an earthenware jar, or in a special fumigating machine, the gas being confined in a fumigating house or, as is more often the case in California, in a tent thrown over a tree. For many years the size of the dose to be given depended entirely upon the guess of each fumigator, there being no uniform practice in this respect. The results of this early guesswork so clearly showed the need of systematism that the State University and the United States Department of Agriculture set experts to work out a more reliable and uniform system of dosage. Prof. C. W. Woodworth was the first to design and use marked tents and published dosage schedules based on measurements.³³⁴ Dr. A. W. Morrill³³⁵ designed the style of marked tents known as "the Morrill system," which is generally used throughout the State. His work was done in Florida, where Prof. C. W. Woodworth first used marked tents several years previously in fumigating for the white fly.³³⁶ Later R. S. Woglum³³⁷ began operations for the United States Department of Agriculture in California and carefully tested "the Morrill system" so as to make its practicability and availability apparent to all of the orchardists.

TENTS

Shape.—In order to conform as near as practicable to the form of a tree, fumigation tents are made in the shape of an octagon (8-sided, Fig. 482). If the tents were square the corners would be a constant and unnecessary annoyance.

For small trees, bell tents were formerly made dome-shaped with a strong hoop sewed around the bottom. Such tents are seldom if ever used at the present time.

³³⁴Bul. No. 152, Cal. Agrcl. Exp. Sta., 1903.

³³⁵Bul. No. 76, Bur. Ent. U. S. Dept. Agric.

³³⁶Bul. No. 67, Fla. Agrcl. Exp. Sta.

³³⁷Bul. Nos. 79, 90 (pts. I and II), Bur. Ent. U. S. Dept. Agric., 1909, 1911.

Size.—The size of a tent naturally depends upon the size of the tree. For young orchards a twenty-foot tent will serve until the trees are about four years old and the tents can then be enlarged by simply sewing a border around the edges. This border is usually made of lighter 6-ounce drilling. In this way an orchard may be

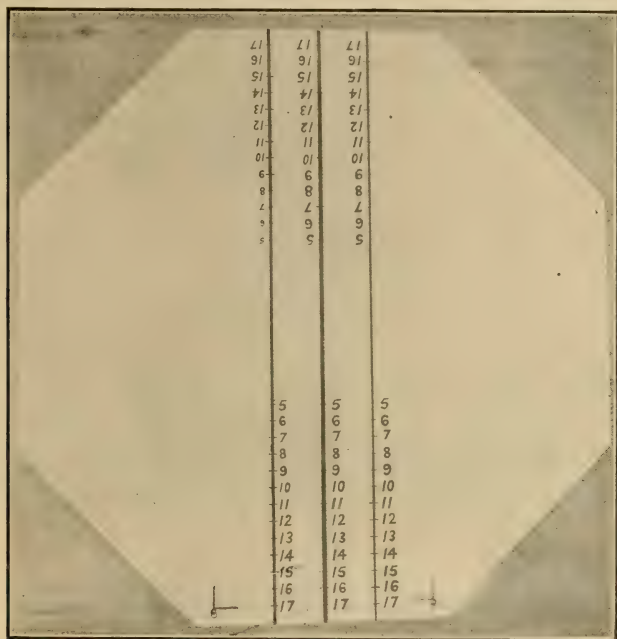


Fig. 482.—Showing shape and Morrill method of marking a fumigating tent.
(After U. S. Dept. Agric.)

carried over until the ordinary larger tents can be used. In fact, many fumigators do use a large tent upon a small tree by placing a suitable square or triangular frame around the tree to support the tent or, if the trees are strong enough, to allow them to support the tents unaided.

For ordinary work 45-foot tents are commonly used and meet all requirements of a full-grown orchard, except for unusually large trees, many of which require 70 or 80-foot tents. It is customary, however, to use two or even three ordinary tents together when there is only an occasional large tree.

Materials.—The life and nature of a fumigation outfit depends upon the quality and care of the tents. Many materials have been recommended and tried; army duck and drills of various weights being those most used. A special tight-woven drill tent was once recom-

mended by R. S. Woglum, but the material, though allowing but a small escape of gas, was not able to stand the rough usage. After several years of trial it is becoming the almost unanimous opinion of fumigators

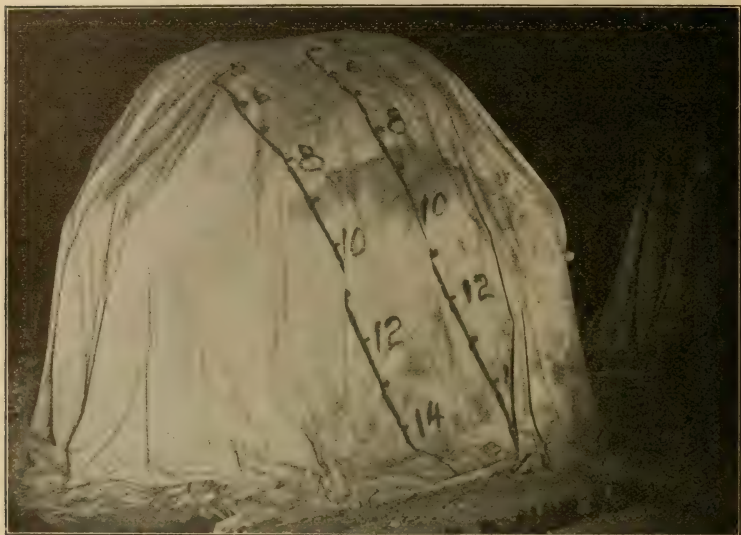


Fig. 483.—Marked fumigating tent over tree. (After Pierce, P. C. Jr. Ent.)

that by far the best of all tent material is a selected 8-ounce army duck. Though somewhat coarse and open, it is able to hold the gas well and may be used almost twice as long as the drills.

Tents should be ordered a little larger to allow for shrinkage when dipped.

Dipping.—To prevent moulding and rotting, new tents are sometimes treated in a tannin bath. A suitable outfit for this work is shown in Fig. 484.

The tank should have a capacity of from two hundred and fifty to three hundred gallons. Oakbark extract of tannin is used at the rate of one pound to every five gallons of water. Six or eight pounds of tannin and the amount of water removed with the tent should be added after each is dipped.

The tannin solution should be brought to a boil and the tents immersed for half an hour, after which they are removed and spread out to dry.

A 45-foot tent will shrink about one foot all around in dipping (allowing for some stretching by use afterward).

The cost of dipping for tannin, fuel, labor, etc., amounts to about \$1.20 to \$1.50 outside of equipment.

The writer is indebted to Mr. R. S. Vaile for the information on shrinkage and cost of work.

Marking.—Because of the shrinkage it is preferable to mark the tents after dipping.

The usual practice, as determined by Dr. A. W. Morrill, consists in making three, one and a half or two-inch parallel lines across the tent three feet apart. Three lines are made in preference to one,

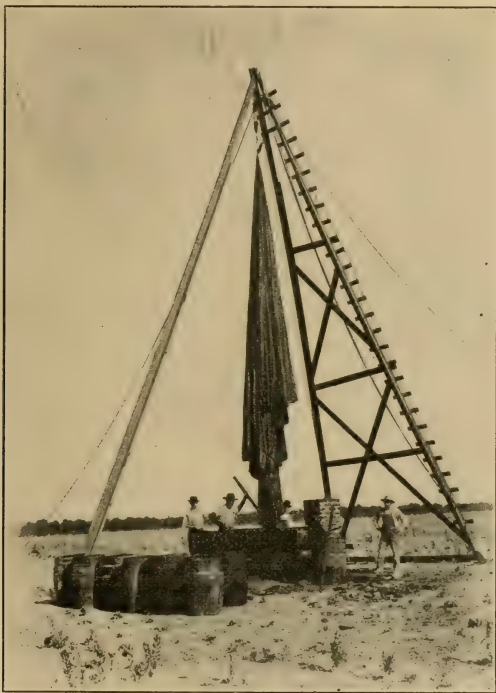


Fig. 484.—Apparatus for dipping tents in tannin to prevent mildew. (After Woglum, U. S. Dept. Agric.)

so that when the tent is put over the tree one of these lines will be sure to pass over the center. The measurements over the tree are ascertained by numbering each foot across the tent, beginning in the middle, and numbering each way, as shown in Fig. 482. The first four numbers are omitted because they are seldom if ever needed. The cost of marking and stenciling the numbers averages about seventy-five cents a tent.

Number for Outfit.—The ordinary fumigating outfit consists of from thirty to forty tents, a number which five men are capable of throw-

ing and dosing at hourly intervals. An increase in apparatus or men for handling and dosing will naturally admit of an increase in this number.

Care.—The greatest care should be exercised to prevent acid coming in contact with the tents for every contact results in a large or



Fig. 485.—A cheap and satisfactory hand chemical cart. (Photo by R. S. Vaile)

small hole. Every day each tent should be carefully examined and all holes covered with sewed patches. Failure to follow these suggestions is sure to result in poor and unsatisfactory work.

CHEMICAL WAGON

Under the old system of scheduling and estimating, the dosage for every tree was sometimes made up at some central point in the orchard and distributed in carriers by hand. The new system of determining the dosage requires the measuring and weighing at each tree, so that a chemical cart or wagon is needed to carry a full supply of acid, cyanide and water in easily available shape.

The sulphuric acid should be kept in an earthenware or lead-lined container capable of excluding air on account of the absorption of large quantities of water and drawn off through a rubber siphon or outlet. An ordinary keg or barrel with faucet will hold the water and a tight box is all that is necessary for the cyanide. Dosage schedules, graduates, clamps, rubber gloves, scales and sufficient light complete the outfit.

FUMIGATING MACHINE

A special fumigating machine has recently been invented in which the gas is almost instantaneously generated and conducted to the tent by means of a rubber hose. So far the work has been more or less experimental, but it has clearly shown the adaptability and advantages of such a method and promises to greatly modify fumi-

gation methods. Such a machine admits of very rapid work and almost entirely eliminates the danger of burning the tents with acid.

Acid Container.—For ordinary work a three, five or ten gallon earthenware jar is sufficient. A lead lid for the top and a three fourths inch iron pipe inserted through a hole in the side near the bottom with a piece of pure rubber tubing six inches long and closed by an acid clamp is a cheap and practical device. Lead-lined tanks are more durable, but also much more expensive.

Water Tank.—As there is two or three times as much water used as acid the water tank must necessarily be larger. For a hand cart a pickle keg is excellent, while a twenty-five or fifty-gallon barrel may be necessary for a large wagon. An extension pipe and faucet furnish the outlet, which should be near that of the acid tank.

Graduates.—The quantity of acid and water used depends entirely upon the amount of cyanide required for a dose. For every ounce of potassium cyanide one fluid ounce of sulphuric acid and three fluid ounces of water are used, while for sodium cyanide one and a half



Fig. 486.—A specially constructed chemical wagon. (Photo by H. S. Fawcett)

fluid ounces of sulphuric acid and two fluid ounces of water are used. As this is a fixed ratio in each case, graduates have been made to measure out the exact amount of the liquid required in the terms of the number of ounces of cyanide; for instance, if it required twelve ounces of sodium cyanide for a dose, the acid graduate is so sealed that it would be filled to the twelve-ounce line, which would mean eighteen fluid ounces, and the water graduate to the twelve-ounce line, which would be twenty-four fluid ounces. Such a scheme makes it unnecessary to make mental calculations and thus avoids mistakes.

ACID GENERATORS

Acid generators are earthenware pots usually made in one-gallon, two-gallon and three-gallon sizes, and with or without lids. The lid has long been recognized as a valuable adjunct to a generator by throwing the gas outward, thus preventing burnings directly above the generator. It also prevents the sputtering over of the acid due to the violent chemical reaction when the cyanide is added. So far there appears to be no lid manufactured which is entirely satisfactory, and the majority of the fumigators still use the open generator. A suitable lid should be light and hinged, so as to admit of easy emptying.

The two-gallon generator is generally used because it more nearly meets the requirements of large and small doses. Care should be exercised not to fill a single pot more than one third full of acid and water before the cyanide is added, as the contents may boil over and much of it be wasted. For large doses use two or more generators to a tree. To prevent unnecessary sputtering, especially when open generators are used, the cyanide is often first placed in small thin paper bags which are dropped directly into the diluted sulphuric acid.

MEASURING THE TENTS

The air space of the tents is usually determined by a schedule based upon the cubical contents of the tent, but in actual field operations the present practice is to determine ounces by taking one per cent of the product of the two dimensions of the tent in feet, thus for a tent which is 20 feet over and 30 feet around we would have $20 \times 30 = 600$. One per cent of this equals six ounces, which is very nearly Woglum's schedule No. 1. The distance over is most easily ascertained by the marked lines across the tent—the sum of the two figures nearest the ground being taken. The distance around is often paced, but careful fumigators use a tapeline, which is certainly the only procedure to be recommended. The tapeline should be numbered in feet on both sides, the numbering of each side being opposite so as to admit of the use of either end without subtraction. A small, light snap is usually sewed to each end, to be fastened to the ring at the top of a short iron pin stuck in the ground to hold the loose end while the tape is carried around the tent. A spring clothespin attached to one end of the tape and snapped to a seam or fold of the tent is a very good way to secure the tape while making measurements.

DOSAGE SCHEDULES

These schedules are printed on fairly stiff paper so that they may be tacked upon a board for the use of the cyanide man. The figures are black and large enough to be plainly seen by the light of a torch or lantern on the darkest night. Half and quarter ounces are omitted because of the difficulty in reading the small fractions at night and because few scales are made to register these small amounts accurately. All less than half ounces are placed in the lower figure, while half ounces or over are placed in the next higher figure. A

more convenient way of fixing up the schedule is to have a cylinder made of zinc, with a narrow slot, the width of a row of figures, covered by a glass, and a wooden roller on the inside, similar to a rolling pin. Each end of the cylinder is closed by a cap with a hole in the center, in which turn the handles of the wooden roller. The chart or

FUMIGATION OF CITRUS TREES IN CALIFORNIA.

DOSAGE SCHEDULE $\frac{3}{4}$ FOR SODIUM CYANID 128-130 (DOSAGES ARE IN OUNCES).

BY R. S. WOOLUM, SPECIAL AGENT.

DISTANCE AROUND (IN FEET).

	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68		
10	2	2	2	2	2																							10	
12	2	2	3	3	3	3																						12	
14	3	3	3	3	3	3	3	3	3	3	3	4																14	
16	3	3	3	3	3	3	3	3	3	3	4	4	4	4														16	
18	3	3	3	3	3	3	4	4	4	4	4	4	4	5														18	
			20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68		
20			3	3	3	4	4	4	4	4	4	5	5	5	5	5	6	6										20	
22				4	4	4	4	4	4	4	5	5	5	5	6	6	6	6	6									22	
24					4	4	4	4	5	5	5	5	6	6	6	6	7	7	7									24	
26						4	5	5	5	5	6	6	6	6	7	8	8	8	8	8	8	8						26	
28							5	5	6	6	6	6	6	7	7	8	8	8	8	8	9	9						28	
								30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68		
30								5	6	6	6	7	7	8	8	8	8	8	8	9	10	11	11	11	11	12	12	30	
32												7	8	8	8	9	9	9	10	10	11	11	11	11	12	12	13	32	
34												8	8	8	9	10	10	11	11	11	11	11	12	12	13	13	13	34	
36												8	8	9	10	10	11	11	11	11	12	13	13	13	13	14	14	36	
38													9	9	10	11	11	11	12	12	13	13	13	14	14	14	15	38	
													40	42	44	46	48	50	52	54	56	58	60	62	64	66	68		
40													9	10	11	11	11	11	12	13	13	14	14	14	14	15	15	15	40
41													11	11	11	11	11	12	13	13	14	14	14	15	15	15	16	41	
42														11	11	12	13	13	14	14	14	14	15	15	15	16	16	42	
43															12	13	13	14	14	14	15	15	15	16	16	17	43		
44																	13	14	14	14	15	15	15	16	16	17	17	44	
																		50	52	54	56	58	60	62	64	66	68		
45																		13	14	14	15	15	15	16	17	17	17	45	
46																		14	14	15	15	15	16	17	17	17	17	46	
47																		14	14	15	15	16	17	17	17	17	18	47	
48																		14	15	15	16	17	17	17	17	18	18	48	
49																		14	15	16	16	17	17	17	17	18	19	49	

This Schedule is recommended for general use against the RED, YELLOW, BLACK, and PURPLE scales.

Where an infestation of people with insects, increase this schedule by

Fig. 487.—Fumigation dosage schedule $\frac{3}{4}$ No. 1 for sodium cyanide. (After R. S. Woolum, Bur. Ent., U. S. Dept. Agric.)

schedule is attached to the roller so as to revolve in the cylinder. The figures of the distances around are pasted along the top of the slot to conform with the like numbers on the schedule. In finding the dosage one has only to turn the roller until the distance over shows at the left-hand end of the slot, the figure at the top of the slot shows the distance around. In this way the chart is kept perfectly dry and bright and the possibilities of making a mistake are reduced to a minimum. This arrangement was first invented by Mr. C. E. McFadden, who uses it on all of his chemical carts.

MISCELLANEOUS EQUIPMENT

Rubber gloves for handling the acid graduate and generators, pure rubber tubing for drawing off the acid, acid clamps or cut-offs to control the flow, a pair of scales registering ounces, thermometer and good lights are as necessary as any of the other equipment.

CHEMICALS

The chemicals used for generating hydrocyanic acid gas in fumigating work are potassium and sodium cyanide, commercial sulphuric acid and water. The cyanide is usually handled in the 200-pound cases and the acid in steel drums weighing from 1,200 to 2,000 pounds.

Cyanide.—For many years previous to the last two, potassium cyanide, 98–99 per cent, was almost entirely used in fumigating. At the present time, however, it has been practically replaced by

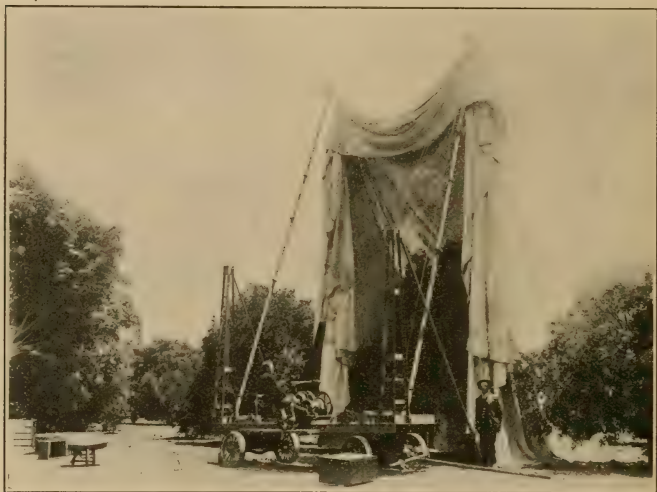


Fig. 488.—The McFadden tent-hoisting machine. (After Woglum, Bur. Ent., U. S. Dept. Agric.)

129–130 per cent sodium cyanide. Sodium cyanide costs more per pound, but because of the greater cyanide content less is needed, thus making it actually the less expensive of the two on the basis of the amount of gas generated. It is also put up in pieces weighing just one ounce each.

Both of the cyanides are good and reliable, and the deciding features will probably always be the supply available and the price.

Sulphuric Acid.—Fumigating sulphuric acid has a specific gravity of about 66 degrees Baumé, containing only traces of nitric acid and arsenic, lead or zinc. It has been the current belief that especially nitric acid caused the burning of the fruit and foliage so often the results of fumigating work, but R. S. Woglum in Bul. No. 90, Part I, page 42, U. S. Dept. Agric., Bureau Entomology, states that this is an erroneous belief. It should always be the aim of every fruit grower to get good grades of sulphuric acid, which is not at all difficult at the present time.

CHEMICAL PROPORTIONS

Potassium Cyanide (98-99%)

Potassium cyanide-----	1	ounce
Sulphuric acid-----	1	fluid ounce
Water-----	3	fluid ounces

Sodium Cyanide (129-130%)

Sodium cyanide-----	1	ounce
Sulphuric acid-----	1½	fluid ounces
Water-----	2	fluid ounces

METHODS OF PROCEDURE

For an outfit of thirty or thirty-five tents five men are required to operate to an advantage. Two men pull the tents and kick in the edges around the bottom. One man, the taper, takes the measurements of the tree and calls them off to the man who weighs out the cyanide. After determining the dosage this man also empties the generators from the row just finished and has them ready for the next trees by the time the chemical cart arrives. The man who weighs the cyanide determines the dose on the schedule from the measurements called out by the man who measures the tents. The cyanide man also lifts the tent so that the last man who measures out the acid and water in the generators may place them well under the tree, after which the cyanide is added. In no case should the acid man touch the tents. While the chemical men are dosing one tree the taper is getting the measurements for the next tree ready in advance. In brief, the procedure is as follows: putting the tents over the trees, measuring and dosing. The string of thirty tents can be easily dosed within forty-five minutes or an hour. Methods of procedure vary considerably, the above being general.

For extra large trees a special tent-hoisting apparatus (Fig. 488) has been devised by Mr. C. E. McFadden, with which a 70 or 80-foot tent can be easily and quickly put over the largest citrus trees.

DOSAGE

The dosage is variable and depends upon the pest to be treated. It is usually stated in terms of the number of ounces of cyanide used. Several field schedules in which the dosages are tabulated are recommended. R. S. Woglum recommends his Schedule No. 1 (potassium cyanide) for red scale, yellow scale, purple scale and black scale, and Dosage Schedule $\frac{3}{4}$ for black scale under favorable conditions. He also recommends Dosage Schedule $\frac{3}{4}$ (sodium cyanide) for black scale, red scale, yellow scale and purple scale (Fig. 487).

Prof. C. W. Woodworth has found in actual fumigation work that the proportion for purple scale, red scale and black scale is about $7\frac{1}{2}$ -5 $\frac{3}{4}$ -4, respectively.

Tent leakage is a very important question which has not yet been sufficiently worked out in practice. Prof. Woodworth has calculated a series of tables to correspond with different degrees of tent leakage. Several instruments have been invented to determine the

leakage of tent materials and these will make it possible to gradually correct the present dosage schedules, which at best are only tentative schemes which have given good results in practice.

LENGTH OF EXPOSURE

The time actually required to generate the gas is very short, but the tents are left over the tree for a considerable time in order to adequately kill the scale insects. The time usually allowed is forty-five minutes. Some shorten the time to thirty minutes, while others insist upon a full hour.

TIME OF OPERATION

Fumigation for red scale, yellow scale and purple scale may be done with fair results at most any time of the year, but if black scale is also present with any one of these the work is usually done during the late fall, winter and early spring months, when the black scale is in the immature stage, in order to avoid the presence of the mature and very resistant gravid females, which do not easily succumb to ordinary treatment. Treatment for the gray citrus scale should be made from August 15th to September 15th.

TEMPERATURE

Fumigation is ordinarily done during the night, when there is less danger to the plant. Cool, cloudy days may admit of some work, but all day operations are liable to result in severe burnings of the fruit and foliage. Excessive coldness is also likely to cause disastrous results to the crop, especially when accompanied with much humidity. It is always advisable to keep a thermometer with the outfit and to suspend operations when the temperature is 70 degrees Fahrenheit or more above zero or when it is 36 degrees Fahrenheit or less. Low temperature should be avoided, especially during damp or wet nights.

Hot, electric winds are also claimed to produce severe burnings and work is generally suspended on such occasions.

BORDEAUX MIXTURE AND BORDEAUX PASTE

Orchards previously sprayed with Bordeaux mixture should not be fumigated, for there have been severe burnings to fruit and foliage as the results of fumigation. It is still a matter of some doubt if injury follows when only the tree trunks and larger limbs are painted with Bordeaux paste. Recent experiments conducted in San Diego County by J. A. Prizer seem to point conclusively that no damage is done in such instances.

THE COMMON NEMATODE OR POTATO EELWORM³³⁸*Heterodera radiculicola* Greef

(Figs. 489, 490)

Eelworms belong to a phylum of animals far below insects and are never considered in a general work on entomology, but, due to the seriousness as well as the wide distribution of this worm as a pest of crops, a brief account of it is herein included.

Description.—The presence of this pest is told by such characteristic injuries as root knot on nursery trees, galls on the roots of tomato vines and the rough, warty surface of potato tubers (Fig. 490). The animal causing the injuries is commonly known as the nematode and was recently given much prominence as the potato eelworm. The males and young, the usual forms of the animal, are microscopic, transparent and shaped much like minute eels. The female is pear-shaped and pearly-white (Fig. 489). The eggs are oval in shape and laid in great numbers.

Life History.—The young eelworms feed upon the roots of various plants, causing galls or knots which may greatly impair growth. The female develops within the affected areas and begins egg-laying, the eggs hatching in a very short time. The winter is passed in the original host, such as nursery stock, if it remains growing in the soil, but if the host is removed they feed upon various plants left in the fields. The young have the ability to encyst themselves so as to resist great extremes of weather and unfavorable conditions, so when once established in the soil it is very difficult to eradicate them.

Nature of Work.—These minute worms, working into the roots of plants, produce very characteristic galls or warts and cause what is commonly known as root knot.

Distribution.—As a producer of root knot this animal is very common throughout the State, but somewhat more abundant in the central and southern parts. As a potato pest it has been reported only from Alameda, Contra Costa, Inyo, Los Angeles, Monterey, Sacramento, San Joaquin, Santa Barbara and Tulare counties.



Fig. 489.—Female bodies of the common nematode or potato eelworm, *Heterodera radiculicola* Greef. Enlarged five times. (Photo by Leroy Childs)

³³⁸Childs, Leroy, Mo. Bul. Cal. Hort. Com., II, pp. 737-756, 1913.

Bessey, Dr. E. A., Bul. No. 217, Par. Pl. Ind., U. S. Dept. Agric., 1911.

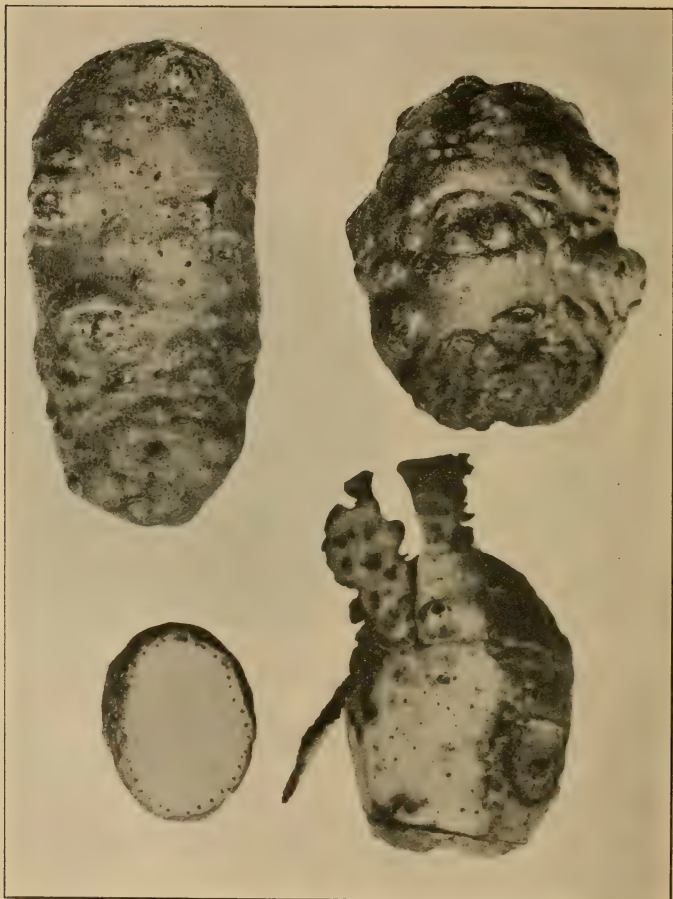


Fig. 490.—Potatoes showing the work of the common nematode or potato eelworm, *Heterodera radiculicola* Greef. The sections show the lesions in the tubers. Natural size. (Photo by L. A. Whitney)

Food Plants.—According to Dr. E. A. Bessey, there are four hundred and eighty species and subspecies of plants affected by root knot. A large number of the garden plants are therefore attacked, as are many of the field crops and fruit trees. For definite information concerning the host plants the reader is referred to pp. 10–22, Bulletin No. 217, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1911.

Control.—The control of this pest is extremely difficult and eradication is almost impossible. In greenhouses the soil may be sterilized with steam or formaldehyde (1 part formaldehyde to 100 parts of water). Summer fallow and frequently turning up the soil and allowing it to dry out will help to reduce the numbers. Irrigated districts are more liable to become infested and are very favorable to the spread of root knot, and in such areas it is especially difficult of control.

INSECT COLLECTIONS

A collection of the most important economic insects is of very great value to any one engaged in the control of insect pests and the building up of such a collection is both instructive and delightful.

Many have come to realize this and have already collected and preserved the insects most common in their respective localities.

To meet the many demands for information and directions for collecting and preserving insects, a few simple directions are given.

COLLECTING

Many do not have time to develop the methods of collecting insects as a specialized part of their work and so do not bother with them

at all. It is not possible to build up a complete collection in one year, even by the most thorough and persistent efforts, but it is quite within one's powers to gradually acquire a very representative lot of insects by being particular to make close observations and to capture all specimens as they are discovered. It is necessary, then, to be always equipped with a few small vials or pill boxes for such emergencies. Fruit growers and gardeners generally collect and send large numbers of insects for determination, which if carefully mounted and preserved soon swell a collection. This gives a state or county official an opportunity to get many insects which he might not himself take for years. A true entomologist can not go out into the open country without capturing at least a few good specimens.

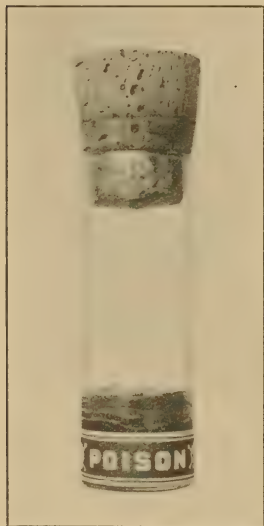


Fig. 491. — A small pocket cyanide bottle for killing insects. Small lumps of cyanide in the bottom are held in place by cotton and several pieces of blotting paper. Slightly reduced. (Original)

Nets.—A good net is indispensable for collecting insects. The general form is somewhat cone-shaped and consists of a metal ring usually about 1 foot in diameter around which is securely fastened a piece of cloth which tapers from the ring to a small rounded end and is about two feet long. For sweeping, the cloth should be of heavy cotton like

denim or a light canvas which will not easily tear. For capturing butterflies and other insects on the wing, bobbinet is much better. Small nets are sometimes made of silk for special work. The handle should be securely fastened to the ring and from two to three feet long for ordinary collecting. A very convenient form is the frame of a collapsible landing fish net with a jointed handle, which may be carried in a traveling bag.

Sieve Nets.—Various types of sieve nets are used for capturing aquatic insects, some in the form of a dipper and others with a net



Fig. 492.—Pinned insects. The white ants at left are pinned through the prothorax; the dragon-fly at the right is pinned through the mesothorax and has the wings spread. (Original)

fastened to the top of a rake. The teeth of the rake serve to loosen up the bottom of the pool or stream and dislodge the insects which are captured in the net just above.

Traps.—Large numbers of insects are attracted by light and may be captured automatically by light traps. One form of light trap is simply a lantern suspended over a pan or tub of water into which the insects fall in their flights about the light. Moths and delicate insects, however, are usually ruined in the water and other insects are often disfigured by the bath. Another type, especially for moths, consists of a large funnel which leads into a cyanide or chloroform jar and the mouth placed near a reflector in front of a light. The insects strike against the funnel and drop into the killing jar beneath.

Many beetles are effectually captured by traps baited with spoiled and decaying meats, fruits and vegetables. A very inexpensive trap consists of a can or jar sunk into the earth until the top is even



Fig. 493.—Pinned insects. Grasshoppers and cricket, pinned through the mesothorax. Two methods of spreading the wings are also shown. (Original)

with the surface. The bait is suspended just over the mouth and the approaching insects fall into the pit and are unable to escape.

KILLING

Insects to be mounted and preserved should be killed as soon after collected as possible. The most popular method of killing is the use of a jar or can containing potassium or sodium cyanide. The cyanide may be kept in the bottom of the jar or can with plaster Paris, or better, with suitable pieces of blotting paper, which absorb the moisture. The lid should be tight, so as to retain all of the fumes, and enough cyanide used to make the killing rapid. Small killing-vials, suitable for the pocket (Fig. 491), are very desirable and easily made. Baking powder cans

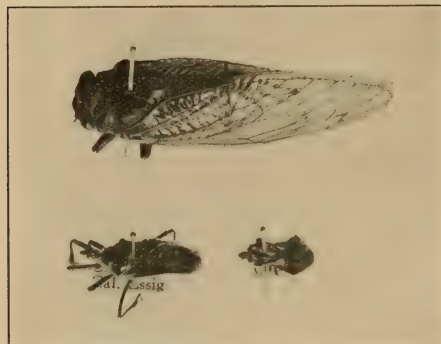


Fig. 494.—Pinned insects. A cicada pinned through the mesothorax at the top and two bugs pinned through the scutellum at the bottom. (Original)

are also excellent containers, as they can not be broken. Due to the poor fitting of the lids, however, they need often to be refilled. In



Fig. 495.—Pinned insects. Beetles, all pinned through the bases of the right elytra. (Original)

preparing such a can, cut a circular piece of blotter to cover the bottom; add the cyanide and pack cotton or other material tightly around it; cover all with several circular, tight-fitting pieces of blotter, and then

cut another piece large enough to form a lining inside the can, reaching from the pieces holding the cyanide to the top. When the lid is on,



Fig. 496.—Pinned insects. Butterflies and a moth, pinned through the mesothorax. The wings are also properly spread. (Original)

this lining will hold the cyanide in the bottom of the can and is also an excellent absorbing surface for any excess moisture. All cyanide killing receptacles should be plainly marked poisonous.

MOUNTING

There are many ways of mounting insects so as to show them to the best advantage, to preserve them longest and most perfectly and to admit of their being studied. The most common methods are pinning them directly in suitable cases or boxes, placing them in glass plaques, tubes and vials, in mounting media like glycerine or balsam on glass slides and in alcohol or formaldehyde in bottles and specimen jars. All mounting work should be done as soon after the insects are killed as possible in order to avoid breaking the appendages which become very stiff and brittle upon drying. However, if they are allowed to become dry they may be perfectly relaxed in a moist chamber and

then safely mounted. Any glass or porcelain dish with a close fitting lid may be used for this purpose. A few layers of blotting paper in



Fig. 497.—Pinned insects. Side view of a butterfly and moth pinned through the mesothorax. The wings are not properly spread in either specimen. (Original)

the bottom serve to hold the moisture and a small amount of flaked naphtha will prevent mildewing. It requires from 12 to 24 hours for relaxing in such a chamber.

Pinning.—Practically all of the adult insects, excepting the very small ones, are pinned. Ordinary house pins can not be used, because



Fig. 498.—Pinned insects. Flies at the top and a bee and wasp at the bottom. All pinned through the mesothorax. (Original)

they are too short and usually too large in diameter. Therefore, special insect pins are manufactured for this purpose. They are about

one and one half inches long and vary in size from No. 000, the finest, to No. 8, the coarsest. Nos. 1, 2 and 3 are sufficient for ordinary purposes. Very small, fine pins, known as *minutien-nadeln*, are used for very small *Diptera* (flies) and *Lepidoptera* (moths) in secondary pinning. Formerly only shiny brass pins were used for all purposes, but as they caused green verdigris in some specimens, they have been largely replaced by black steel pins, which are also stiffer and generally much more satisfactory. Always specify black pins when ordering. The position of the pin varies considerably, but with the exception of the order *Coleoptera* (beetles) and the suborder *Heteroptera* (bugs), practically all are pinned through the mesothorax. Some of the *Aptera* are pinned through the mesothorax and the *Corrodentia* (white ants) are pinned through the prothorax. The beetles are pinned through the right elytrum or wing cover, near the base, as shown in Fig. 495. The bugs are pinned through the scutellum and the metathorax (Fig. 494).

Secondary Pinning.—Very small insects, especially flies and moths, are mounted upon the *minutien-nadeln*, which are pinned into a piece of cork or cardboard, the length of a point, supported on a regular No. 2 insect pin. This allows the smallest specimens to be placed in the collection in perfect harmony with the large ones.

Points.—All small insects, including the beetles, parasitic *Hymenoptera*, lantern flies, tree-hoppers, spittle insects, leaf-hoppers, jumping plant lice, white flies, etc., are mounted on small ledger paper or cardboard points (Fig. 499). White shellac or beetle glue³³⁹ is used to fasten them to the points. The size of the points usually differs with each entomologist, but one that is gaining much favor is 9 mm. long, 1 mm. at the base and tapering to a point, as shown in Fig. 499. The specimen should be placed on the point so that it looks away from you when the pin is to the right of the insect, as shown in

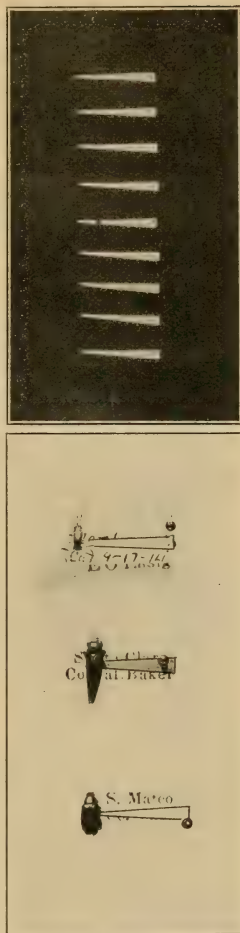


Fig. 499.—Top picture shows a good-shaped point, enlarged slightly more than one and one half times. It should be 9 mm. long. Insects mounted on points at bottom, enlarged twice. (Original)

³³⁹Beetle glue is prepared as follows:

Alcohol (95 per cent)	8 parts
Carbolic acid	2 parts
Sugar	30 parts
Gum arabic	60 parts
Water	45 parts

Fig. 499. Great care should be exercised to see that the specimen is perfectly straight, at right angles to the point and that all the appendages are free. In ladybird beetles the point should not extend quite to the middle of the sternum.

Spreading.—Insects which are classified entirely or partially by wing venation or coloration are placed upon a stretching board when fresh, or after being relaxed and the wings properly stretched, fastened

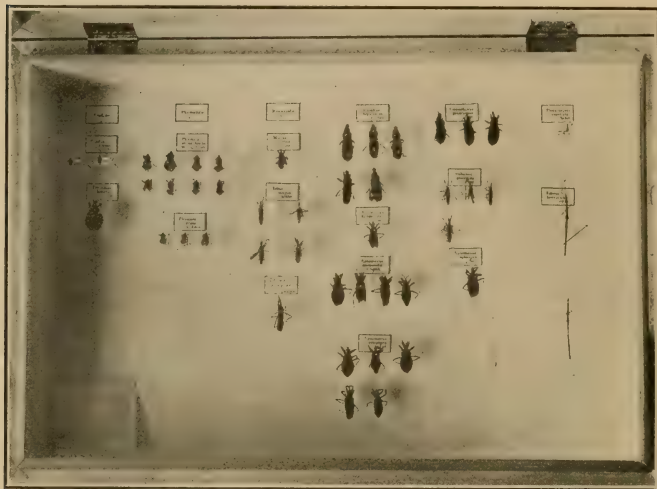


Fig. 500.—Insects pinned in a Schmitt insect box. A small sack containing flaked naphtha is in the lower left corner. (Original)

and allowed to become thoroughly dry before they are removed and placed into permanent quarters. The hind margins of the front wings of a properly stretched insect should be at right angles to the main axis of the body, as shown in Fig. 496.

Butterflies and moths may be safely preserved in small paper triangles until ready for spreading.

CASES FOR PINNED INSECTS

By far the most satisfactory containers for pinned insects are the Schmitt insect boxes, which are practically dust and insect proof. Specially constructed cases with glass tops are excellent for exhibition purposes. Small sacks of flaked naphtha should be fastened in the corners of the boxes to keep out destructive museum pests (Fig. 500).

GLASS VIALS

Scale insects (*Coccida*) are easily handled and preserved in small glass shell vials, as shown in Fig. 502. Life histories of other insects for exhibition purposes may also be mounted in small or large glass shell vials.

PLAQUES OR GLASS MOUNTS

Nearly all insects may be mounted in plaques with glass fronts and cardboard backs. These make excellent exhibits to hang upon the walls. Special mounts are prepared in the form of small cardboard boxes filled with cotton upon which the specimens rest and over which a glass-faced cover is tightly fitted.

GLYCERINE

Certain small soft-bodied scale insects, plant lice, young bugs, larvæ, etc., are often mounted directly on glass slides under a glass cover in glycerine prepared by adding one part of acetic acid to ten parts of glycerine jelly. Specimens may be

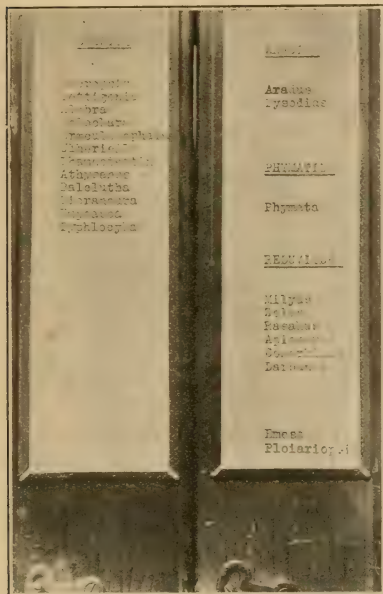


Fig. 501.—Method of labeling insect boxes. The cards may be taken out at will. The family and generic names appear on the outside. (Original)



Fig. 502.—Method of preserving scale insects in glass vials. Natural size. (Original)

mounted without killing or clearing into this or prepared as directed for mounting in Canada balsam.

CANADA BALSAM

For microscopical study, scale insects, plant lice, thrips, mites, etc., are permanently mounted on slides in Canada balsam which has been dissolved in xylol. Specimens are mounted directly in the balsam, either alive or freshly killed, and when so done usually retain their

original shapes perfectly, but are not suitable for microscopic study for several months. By far the most satisfactory method of mounting scale insects is to first boil them in potassium hydroxide (KOH) or sodium hydroxide (NaOH); thoroughly wash them in water; dehydrate by carrying through solutions of 30 per cent, 78 per cent and 95 per cent or absolute alcohol; clear in xylol, cedar oil or clove oil and mount directly into balsam.

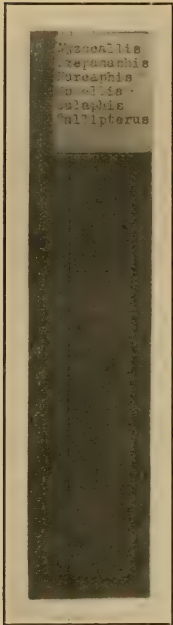


Fig. 503.—Wooden box for microscopic slides. Such a box holds 25 thick and 50 thin slides. Reduced one half. (Original)

An excellent method of mounting the others listed above is as follows: kill by pouring over them boiling 95 per cent or absolute alcohol; clear in xylol, cedar oil or clove oil, and mount directly into balsam. Glass slides and cover glasses are necessary for such mounts.

PRESERVING LARVÆ

Caterpillars are very often preserved by the inflating method, which consists in removing the viscera, inflating the bodies and drying them over an oven until they become rigid. The original shape, color and much of the vestiture are thus retained in almost perfect condition.

Caterpillars and the larvæ of other insects are also excellently preserved by first boiling them in water and placing them directly in a permanent solution prepared as follows:

Alcohol (95 per cent)	15 c.c.
Formalin (40 per cent)	15 c.c.
Water (distilled)	120 c.c.

SENDING INSECTS BY MAIL

Insects sent through the mail for determination should be well packed in a small box, so that they can not be crushed in transit, and should be securely packed in cotton or bits of paper, so they can not rattle around and lose all or most of the appendages. Alcoholic specimens may be sent in regular mailing tubes without danger of breaking. All specimens should be sent in large numbers and accompanied with the name of the food plant, locality, date of collection and the name of the collector and sender.

ERRATA.

- Page 28.** The synonymy of the common termite is as follows:
Leucotermes lucifugus (Rossi)
(*Termes lucifugus* Rossi)
(Thos. E. Snyder, Bul. No. 94, pt. ii, Bur. Ent., U. S. Dept. Agric.,
p. 17, 1915.)
- Page 80.** The spelling of the scientific name of the arborvitæ plant louse is given
by Del Guercio in Redia, Vol. V, pp. 287-289, 1909, as follows:
Lachniella tujafilina Del Guercio instead of *Lachnus tujafalinus* as
given in the text.
- Page 154.** *Tomocera* should be changed to *Diplogaster*.
- Page 193.** The spelling of the specific name of the black Parlatoria should be
ziziphus and not *zizyphus*.
- Page 327.** *Macrosiphum destructor* should read *Macrosiphum pisi*.

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